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(54) **Noise suppression for sending voice with binaural microphones**

Rauschunterdrückung zum Senden von Sprache mit binauralen Mikrofonen

Suppression du bruit pour envoi vocal avec microphones binauraux

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Description

BACKGROUND

[0001] The present invention relates generally to sound systems for mobile devices and, more particularly to techniques for suppressing background noise in portable audio devices using dual-microphone headsets.

[0002] Mobile devices, such as mobile phones, are increasingly used with so-called hands-free technology, for reasons of both safety and convenience. This hands-free technology frequently includes audio headsets of various configurations, including both wired and wireless headsets.

[0003] Dual-microphone technology is now being applied to mobile handsets, to facilitate sophisticated noise suppression techniques. In a typical configuration, one microphone is positioned close to the user's mouth, to capture the voice, while another is positioned elsewhere, such as on the back of the handset, to capture background noise. An audio processing circuit, generally based on a specialized digital signal processor (DSP) effectively subtracts the background noise from the signal containing the user's voice, to produce a reduced-noise signal.

[0004] An audio headset for telephony applications typically includes two earpieces, which generally produce monaural sound in the context of a phone call but may produce stereophonic sound for other applications, such as music playback. These audio headsets conventionally include only a single microphone, for capturing the user's voice during a phone call. However, interest in dual-microphone headsets for mobile telephony applications is growing.

[0005] US 2009/268931 A1 (ANDREA DOUGLAS ET AL), 29 October 2009, discloses a noise cancelling audio transmitting/receiving device e.g. stereo headset. The device has microphones (250) receiving an acoustic signal and outputting as an electrical signal, where the microphones are mounted on an outputting unit e.g. earphone (260). A processing unit applies a frequency domain adaptive filter and an averaging filter on the signal. The processing unit calculates beam, beam reference, reference average and noise estimation based on output of the averaging filter to update filter coefficients of the adaptive filter, and applies the adaptive filter to the output of the averaging filter.

SUMMARY

[0006] According to the invention, a method for suppressing noise using a dual-microphone headset as defined in claim 1 and a noise-suppression system as defined in claim 7 are provided. The dependent claims define preferred or advantageous embodiments of the invention. Noise-suppressing techniques using a dual-microphone headset are disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

Figure 1 illustrates a cellular handset and dual-microphone headset according to some embodiments of the present invention.

Figure 2 is a process flow diagram illustrating an example technique for suppressing noise using a dual-microphone headset.

Figure 3 schematically illustrates an audio-processing circuit.

Figure 4 illustrates functional details of an example correlator circuit.

DETAILED DESCRIPTION

[0008] Referring now to the drawings, a noise-suppression system according to one exemplary embodiment of the present invention is shown therein and indicated generally by the numeral 100. In Figure 1, the illustrated embodiment comprises a mobile phone 110 with a wired headset 120 connected thereto. Those skilled in the art will appreciate that other embodiments of the system pictured in Figure 1 may involve other user devices with communication capabilities, such as a computing tablet, laptop computer, audio player, or other mobile device. Likewise, while system 100 includes a handset coupled to a wired headset 120, the inventive techniques disclosed herein are equally applicable to wireless headset devices, such as those that communicate with a nearby handset using Bluetooth® short-range wireless technology.

[0009] As briefly discussed above, some dual-microphone systems implemented on wireless handsets use one microphone that is positioned close to the expected position of the user's mouth, with a second, "remote," microphone positioned away from the user's mouth. The noise-suppression techniques used in these systems operate on the premise that the audio signals from these two microphones will have similar levels of background noise, but drastically different levels of the desired voice signal. To the extent that this is true, subtracting the signal obtained from the remote microphone from the signal obtained by the voice-collecting microphone should suppress all or part of the background noise. Thus, the basic principle behind these systems is that the components of the microphone signals that are most highly correlated, i.e., the background noise, are suppressed. Various feedback techniques, filtering processes, and the like may be employed to further improve the operation of such noise-suppression systems.

[0010] Systems according to the present invention, on the other hand, are based on a different premise. If a microphone is placed in, at, or near each of the user's ears, the acoustic channel traveled by the user's voice to each microphone (whether through the air, through the user's skull and jaw, or both) will be very similar. The same is true if two so-called throat microphones, which pick up sound through sensors in direct contact with the neck, are placed in symmetric (or close to symmetric) locations on each side of the user's neck. In either case, the two microphone signals will each have a very similar, i.e., highly-correlated, voice component. On the other hand, at least some elements of background noise picked up by the two microphones will be uncorrelated. This is particularly true for microphones positioned in the user's ear or very close to the head, as the user's head will block the path between certain noise sources and one microphone, but not the other. Combining the two microphone signals in a manner that emphasizes correlated components of the signals, relative to the uncorrelated components, will suppress these noise components.

[0011] Figure 2 is a process flow diagram illustrating an example approach to noise-suppression according to these principles. As shown at block 210, first and second audio input signals are generated, at first and second microphones in a dual-microphone headset. As noted above, the headset may be wireless or wired. These microphone signals are then correlated, as shown at block 220, to produce a correlation signal. (As used herein, the term "correlation," is generally intended to refer to a measure of the similarity between two signals. Thus, unless otherwise indicated, the term "correlation" is synonymous with "cross-correlation.") The two microphone signals are also combined, as indicated at block 230, to form an intermediate combined audio signal. The amplitude of the combined audio signal is then selectively varied, based on the result of the correlation, as shown at block 240. This varying of the amplitude, which may be performed using a variable-gain amplifier, for example, emphasizes correlated components of the first and second audio input signals, relative to uncorrelated components.

[0012] In particular, when the two signals are highly correlated, the gain applied to the combined signal is increased. Conversely, when the correlation between the two signals is low, the gain applied to the combined signal is decreased. Any of a wide variety of transfer functions between the correlation output and the applied gain may be used. The most appropriate transfer function will depend at least partly on the microphone characteristics and the precise physical configuration of the headset - an appropriate transfer function may be determined experimentally by testing a range of transfer functions against the specific hardware. In some cases, multiple transfer functions may be preprogrammed into a user device; these transfer functions may be mapped to particular headset configurations, in some embodiments. In others, the user may be permitted to select a preferred noise-suppression transfer function; in still others, the audio processing circuit may be configured to analyze the background noise, using sampled data from one or both microphone inputs, and to dynamically select or adapt a transfer function based on one or more characteristics of the background noise.

[0013] Figure 3 is a block diagram of a noise-suppressing system configured to suppress noise according to the technique illustrated in Figure 2. Figure 3 thus illustrates a pair of microphones 310, coupled to an audio processing circuit 300. Audio processing circuit 300 includes an audio pre-processing circuit 320, which includes, in some embodiments, amplification and filtering. In some embodiments, as will be discussed in further detail below, audio pre-processing circuit 320 further includes an analog-to-digital converter (ADC) coupled to each of the analog signals from microphones 310.

[0014] The audio signals from audio pre-processing circuit 320 (whether in analog or digital form) are provided to combiner circuit 330 and correlator 340. Combiner circuit 330 combines the two signals to form an intermediate audio signal that is fed to variable-gain amplifier 350. Correlator circuit 340 performs a correlation between the two signals to generate a correlation signal - the correlation signal is used to vary the gain of variable-gain amplifier 350, resulting in the emphasis of correlated components of the two microphone signals, relative to uncorrelated components.

[0015] The signal processing in the process illustrated in Figure 2, and in the combiner 330, correlator 340, and variable-gain circuit 350 of Figure 3, may be in the analog domain, the digital domain, or some combination of both. For example, the signals from each microphone may be digitized, using conventional digital sampling techniques, close to the "front end" of the system, i.e., shortly after the acoustic energy collected by the microphone is converted into an electrical signal. Analog conditioning of the signal prior to digitization may include only amplification and basic filtering, in some cases. In these systems, the subsequent processing of the signals, i.e., the correlation, combining, and variable gain amplification, is performed in the digital domain, using a digital signal processor. As will be discussed in further detail below, the digital approach allows for the greatest flexibility in choosing the type or types of correlation that will be performed.

[0016] In other embodiments, the correlation of the two microphone signals may be performed in the analog domain. In this case, correlator circuit 340 may comprise, for example, an audio mixer circuit and a low-pass filter. The low-pass filter in this embodiment establishes a time constant for the correlation process - two signals that have similar amplitudes for a period of time on the order of this time constant will yield a high correlation value, while binaural signals that do not track one another in amplitude will produce lower correlation values.

[0017] Similarly, the two microphone signals can be combined using an analog summing circuit, in which case combiner circuit 330 may comprise, for example, a summing amplifier. In these embodiments, the analog correlation signal from the correlator may be used to drive an analog variable-gain amplifier operating on the combined signal from the summing circuit, thus emphasizing correlated components of the microphone signals that appear in the combined signal.

[0018] In some embodiments, most of the audio processing in audio processing circuit 300 is performed in the digital domain, using one or more suitably programmed microprocessors, special-purpose digital signal processors, as well as, in some cases, specially designed digital logic. In these digital systems, then, audio processing circuit 300 is implemented in part with at least one processor and associated memory, the memory containing program instructions in the form of software and/or firmware, for execution by the at least one processor. Thus, for example, the amplitude correlation and filtering process described above can be readily implemented using well-known digital signal processing techniques.

[0019] One advantage to a digital implementation of the system of Figure 3 is that the correlation between the two audio input signals can be performed in one or more of several different domains. Amplitude correlation between the two signals is readily calculated from digital samples of the two microphone signals. By delaying one of the signals relative to the other before (e.g., by shifting one signal by one or more samples), various correlations in the time-domain can be performed. In this manner, for example, signals that are highly correlated in time, i.e., with very small delay differences, can be emphasized relative to signals that appear in both microphone signals but with larger differences in arrival time. Because the propagation paths for the user's voice to the binaural microphone inputs are symmetric, or very nearly so, voice signals from the headset user will be highly time-correlated, and will be emphasized relative to background noise.

[0020] If the digitized sample stream is converted into frequency domain samples using, for example, a fast-Fourier transform (FFT) algorithm, then correlator circuit 340 can perform a frequency-domain correlation between the two signals. Furthermore, the results of two or more different types of correlation are combined. Thus, for example, frequency components having very similar amplitude profiles in the binaural microphone inputs can be emphasized, relative to frequency components that exhibit significantly different amplitudes in the two inputs. An even more general example of this is shown in Figure 4, where correlator 340 performs three correlation functions, time correlation 410, frequency correlation 420, and amplitude correlation 430, and sums the results in summer 440. The combined correlation signal (which may be an unequally weighted sum of the multiple correlation results, in some embodiments) is then used to selectively adjust the amplitude of the audio signal formed by combining the two microphone signals, thus emphasizing correlated components of the first and second audio input signals.

Claims

1. A method for suppressing noise using a dual-microphone headset (120), the method comprising:

   generating first and second audio input signals (210) from first and second microphones (310) placed in or near user's ears, or placed on each side of the user's throat;
   correlating the first and second audio input signals (220) to produce a correlation signal, wherein correlating the first and second audio input signals (220) comprises at least two of:

      a frequency-domain correlation (420);
      a time-domain cross-correlation (410); and
      an amplitude correlation (430);

   summing the first and second audio input signals (230), to produce an intermediate audio signal; and generating an output audio signal by selectively adjusting the amplitude of the intermediate audio signal, based on the correlation signal, to emphasize correlated components of the first and second audio input signals, relative to uncorrelated components (240).

2. The method of claim 1, wherein the first and second audio input signals (210) and the correlation signal (220) are analog signals, and the correlation signal is used to control an analog variable-gain amplifier circuit to generate the output audio signal.

3. The method of claim 1, wherein the first and second audio input signals (210) are digital signals generated by sampling first and second analog signals collected at the first and second microphone (310) inputs.

4. The method of any one of claims 1-3, wherein correlating the first and second audio input signals (210, 220) comprises a time-domain cross-correlation (410).

5. The method of any one of claims 1-4, wherein correlating the first and second audio input signals (220) comprises a frequency-domain cross-correlation (420).

6. The method of any one of claims 1-5, wherein correlating the first and second audio input signals (220) comprises an amplitude cross-correlation (430).

7. A noise-suppression system, comprising:

   a dual-microphone headset (120) configured to provide first and second audio input signals (210) from first and second microphones (310) configured for placement in or near a user's ears, or on each side of the user's throat; and
   an audio processing circuit (300) comprising:

      a correlator circuit (340) configured to correlate the first and second audio input signals (220) to produce a correlation signal, wherein the correlator circuit (340) is configured to correlate the first and second audio input signals (220) using at least two of:

a frequency-domain correlation (420);
a time-domain cross-correlation (410); and
an amplitude correlation (430);

a summing circuit (330) configured to sum the first and second audio input signals (230), to produce an intermediate audio signal;
and a gain circuit (350) configured to generate an output audio signal by selectively adjusting the amplitude of the intermediate audio signal, based on the correlation signal, to emphasize correlated components of the first and second audio input signals, relative to uncorrelated components.

8. The noise-suppression system of claim 7, wherein the first and second audio input signals and the correlation signal are analog signals, and wherein the gain circuit (350) includes an analog variable-gain amplifier circuit (350) controlled by the correlation signal.

9. The noise-suppression system of claim 7, wherein the audio processing circuit (300) further comprises a sampling circuit configured to digitize the first and second audio input signals, and wherein the correlator circuit (340) is configured to correlate the digitized first and second audio input signals (220).

10. The noise-suppression system of any one of claims 7-9, wherein the correlator circuit (340) is configured to correlate the first and second audio input signals (220) using a time-domain cross-correlation (410).

11. The noise-suppression system of any one of claims 7-10, wherein the correlator circuit (340) is configured to correlate the first and second audio input signals (220) using a frequency-domain cross-correlation (420).

12. The noise-suppression system of any one of claims 7-11, wherein the correlator circuit (340) is configured to correlate the first and second audio input signals (220) using an amplitude cross-correlation (430).

Patentansprüche

1. Verfahren zum Unterdrücken von Geräuschen unter Verwendung eines Doppelmikrofon-Headsets (120), wobei das Verfahren umfasst:

Erzeugen eines ersten und zweiten Audioeingangssignals (210) von einem ersten und zweiten Mikrofon (310), welche in oder in der Nähe von Benutzerohren angeordnet sind oder an jeder Seite des Benutzerhalses angeordnet sind;
Korrelieren des ersten und zweiten Audioeingangssignals (220), um ein Korrelationssignal zu erzeugen, wobei das Korrelieren des ersten und zweiten Audioeingangssignals (220) mindestens zwei von:

einer Frequenzbereichskorrelation (420);
einer Zeitbereichskreuzkorrelation (410); und
einer Amplitudenkorrelation (430);

umfasst;
Summieren des ersten und zweiten Audioeingangssignals (230), um ein Zwischenaudiosignal zu erzeugen; und
Erzeugen eines Audioausgangssignals durch wahlweises Einstellen der Amplitude des Zwischenaudiosignals basierend auf dem Korrelationssignal, um korrelierte Komponenten des ersten und zweiten Audioeingangssignals relativ zu unkorrelierten Komponenten (42) hervorzuheben.

2. Verfahren nach Anspruch 1, wobei das erste und zweite Audioeingangssignal (210) und das Korrelationssignal (220) Analogsignale sind, und wobei das Korrelationssignal verwendet wird, um einen analogen Verstärkerschaltkreis mit veränderlicher Verstärkung zu steuern, um das Audioausgangssignal zu erzeugen.

3. Verfahren nach Anspruch 1, wobei das erste und zweite Audioeingangssignal (210) Digitalsignale sind, welche durch Abtasten eines ersten und zweiten Analogsignals erzeugt werden, welche an dem ersten und zweiten Mikrofoneingang (310) aufgenommen werden.

4. Verfahren nach einem der Ansprüche 1-3, wobei das Korrelieren des ersten und zweiten Audioeingangssignals (210, 220) eine Zeitbereichskreuzkorrelation (410) umfasst.

5. Verfahren nach einem der Ansprüche 1-4, wobei das Korrelieren des ersten und zweiten Audioeingangssignals (220) eine Frequenzbereichskreuzkorrelation (420) umfasst.

6. Verfahren nach einem der Ansprüche 1-5, wobei das Korrelieren des ersten und zweiten Audioeingangssignals (220) eine Amplitudenkreuzkorrelation (430) umfasst.

7. Geräuschunterdrückungssystem umfassend:

ein Doppelmikrofon Headset (120), welches ausgestaltet ist, ein erstes und zweites Audioeingangssignal (210) von einem ersten und zweiten Mikrofon (310) bereitzustellen, welche für eine Anordnung in oder in der Nähe von Benutzerohren oder an jeder Seite des Benutzerhalses ausgestaltet sind; und
einen Audioverarbeitungsschaltkreis (300), umfassend:

einen Korrelatorschaltkreis (340), welcher ausgestaltet ist, das erste und zweite Audioeingangssignal (220) zu korrelieren, um ein Korrelationssignal zu erzeugen, wobei der Korrelatorschaltkreis (340) ausgestaltet ist, das erste und zweite Audioeingangssignal (220) unter Verwendung von mindestens zwei von:

einer Frequenzbereichskorrelation (420);
einer Zeitbereichskreuzkorrelation (410); und
einer Amplitudenkorrelation (430);

zu korrelieren;

einen Summierschaltkreis (330), welcher ausgestaltet ist, das erste und zweite Audioeingangssignal (230) zu summieren, um ein Zwischenaudiosignal zu erzeugen; und
einen Verstärkungsschaltkreis (350), welcher ausgestaltet ist, ein Audioausgangssignal durch wahlweises Einstellen der Amplitude des Zwischenaudiosignals basierend auf dem Korrelationssignal zu erzeugen, um korrelierte Komponenten des ersten und zweiten Audioeingangssignals relativ zu unkorrelierten Komponenten hervorzuheben.

8. Geräuschunterdrückungssystem nach Anspruch 7, wobei das erste und zweite Audioeingangssignal und das Korrelationssignal Analogsignale sind, und wobei der Verstärkungsschaltkreis (350) einen analogen Verstärkungsschaltkreis (350) mit veränderlicher Verstärkung aufweist, welcher von dem Korrelationssignal gesteuert wird.

9. Geräuschunterdrückungssystem nach Anspruch 7, wobei der Audioverarbeitungsschaltkreis (300) ferner einen Abtastschaltkreis umfasst, welche ausgestaltet ist, das erste und zweite Audioeingangssignal zu digitalisieren, und wobei der Korrelatorschaltkreis (340) ausgestaltet ist, das digitalisierte erste und zweite Audioeingangssignal (220) zu korrelieren.

10. Geräuschunterdrückungssystem nach einem der Ansprüche 7-9, wobei der Korrelatorschaltkreis (340) ausgestaltet ist, das erste und zweite Audioeingangssignal (220) unter Verwendung einer Zeitbereichskreuzkorrelation (410) zu korrelieren.

11. Geräuschunterdrückungssystem nach einem der Ansprüche 7-10, wobei der Korrelatorschaltkreis (340) ausgestaltet ist, das erste und zweite Audioeingangssignal (220) unter Verwendung einer Frequenzbereichskreuzkorrelation (420) zu korrelieren.

12. Geräuschunterdrückungssystem nach einem der Ansprüche 7-11, wobei der Korrelatorschaltkreis (340) ausgestaltet ist, das erste und zweite Audioeingangssignal (220) unter Verwendung einer Amplitudenkreuzkorrelation (430) zu korrelieren.

Revendications

1. Procédé de suppression du bruit à l'aide d'un casque d'écoute à microphone double (120), le procédé comprenant :

la génération de premier et second signaux d'entrée audio (210) à partir de premier et second microphones (310) placés dans ou à proximité des oreilles d'un utilisateur, ou placés de chaque côté du cou d'un utilisateur ;
la corrélation des premier et second signaux d'entrée audio (220) afin de produire un signal de corrélation, la corrélation des premier et second signaux d'entrée audio (220) comprenant au moins deux de :

une corrélation de domaines de fréquences (420) ;
une corrélation croisée de domaine temporel (410) ; et
une corrélation d'amplitude (430) ;

l'addition des premier et second signaux d'entrée audio (230), afin de produire un signal audio intermédiaire ; et
la génération d'un signal audio de sortie en ajustant sélectivement l'amplitude du signal audio intermédiaire, sur la base du signal de corrélation, afin de souligner les composantes corrélées des premier et second signaux d'entrée audio, par rapport aux composantes non corrélées (240).

2. Procédé selon la revendication 1, dans lequel les premier et second signaux d'entrée audio (210) et le signal de corrélation (220) sont des signaux analogiques, et le signal de corrélation est utilisé pour contrôler un circuit d'amplification de gain variable analogique afin de générer le signal audio de sortie.

3. Procédé selon la revendication 1, dans lequel les premier et second signaux d'entrée audio (210) sont des signaux numériques générés en échantillonnant des premier et second signaux analogiques collectés au niveau des entrées des premier et second microphones (310).

4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel la corrélation des premier et second signaux d'entrée audio (210, 220) comprend une corrélation croisée de domaine temporel (410).

5. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel la corrélation des premier et second signaux d'entrée audio (220) comprend une corrélation croisée de domaine de fréquences (420).

6. Procédé selon l'une quelconque des revendications 1 à 5, dans lequel la corrélation des premier et second signaux d'entrée audio (220) comprend une corrélation croisée d'amplitude (430).

7. Système de suppression de bruit, comprenant :

un casque d'écoute à microphone double (120) configuré pour fournir des premier et second signaux d'entrée audio (210) à partir de premier et second microphones (310) configurés pour être placés dans ou à proximité des oreilles d'un utilisateur, ou de chaque côté du cou d'un utilisateur ; et
un circuit de traitement audio (300) comprenant :

un circuit de corrélation (340) configuré pour corréler les premier et second signaux d'entrée audio (220) afin de produire un signal de corrélation, le circuit de corrélation (340) étant configuré pour corréler les premier et second signaux d'entrée audio (220) en utilisant au moins deux de :

une corrélation de domaine de fréquences (420) ;
une corrélation croisée de domaine temporel (410) ; et
une corrélation d'amplitude (430) ;

un circuit d'addition (330) configuré pour additionner les premier et second signaux d'entrée audio (230), afin de produire un signal audio intermédiaire ; et
un circuit de gain (350) configuré pour générer un signal audio de sortie en ajustant sélectivement l'amplitude du signal audio intermédiaire, sur la base du signal de corrélation, afin de souligner les composantes corrélées des premier et second signaux d'entrée audio, par rapport aux composantes non corrélées.

8. Système de suppression du bruit selon la revendication 7, dans lequel les premier et second signaux d'entrée audio et le signal de corrélation sont des signaux analogiques, et dans lequel le circuit de gain (350) comprend un circuit d'amplification de gain variable analogique (350) contrôlé par le signal de corrélation.

9. Système de suppression du bruit selon la revendication 7, dans lequel le circuit de traitement audio (300) comprend en outre un circuit d'échantillonnage configuré pour numériser les premier et second signaux d'entrée audio, et dans lequel le circuit de corrélation (340) est configuré pour corréler les premier et second signaux d'entrée audio numérisés (220).

10. Système de suppression du bruit selon l'une quelconque des revendications 7 à 9, dans lequel le circuit de corrélation (340) est configuré pour corréler les premier et second signaux d'entrée audio (220) en utilisant une corrélation croisée de domaine temporel (410).

11. Système de suppression du bruit selon l'une quelconque des revendications 7 à 10, dans lequel le circuit de corrélation (340) est configuré pour corréler les premier et second signaux d'entrée audio (220) en utilisant une corrélation croisée de domaine de fréquences (420) .

12. Système de suppression du bruit selon l'une quelconque des revendications 7 à 11, dans lequel le circuit de corrélation (340) est configuré pour corréler les premier et second signaux d'entrée audio (220) en utilisant une corrélation croisée d'amplitude (430).

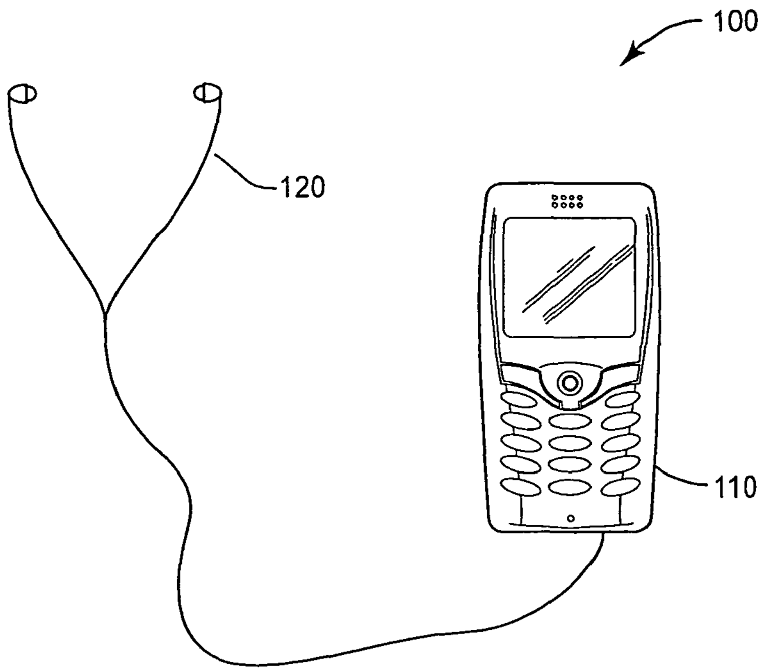
100
120
110

FIG. 1

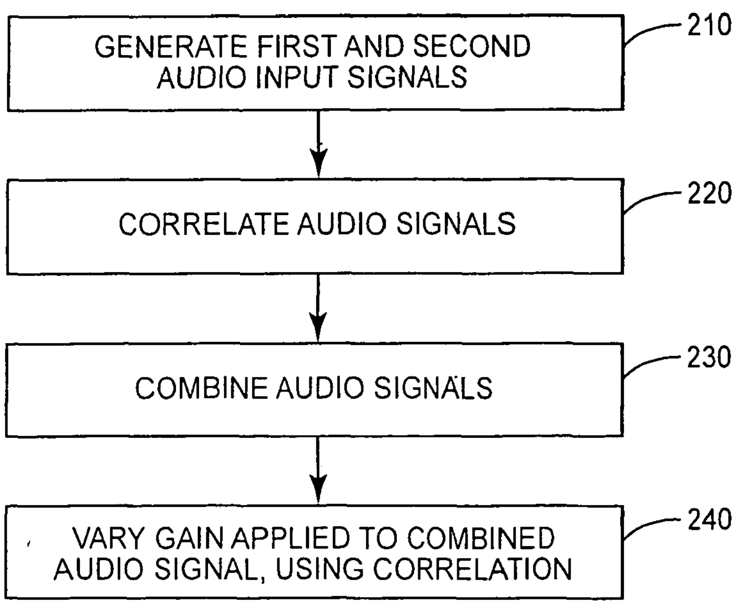
GENERATE FIRST AND SECOND AUDIO INPUT SIGNALS
210
CORRELATE AUDIO SIGNALS
220
COMBINE AUDIO SIGNALS
230
VARY GAIN APPLIED TO COMBINED AUDIO SIGNAL, USING CORRELATION
240

FIG. 2

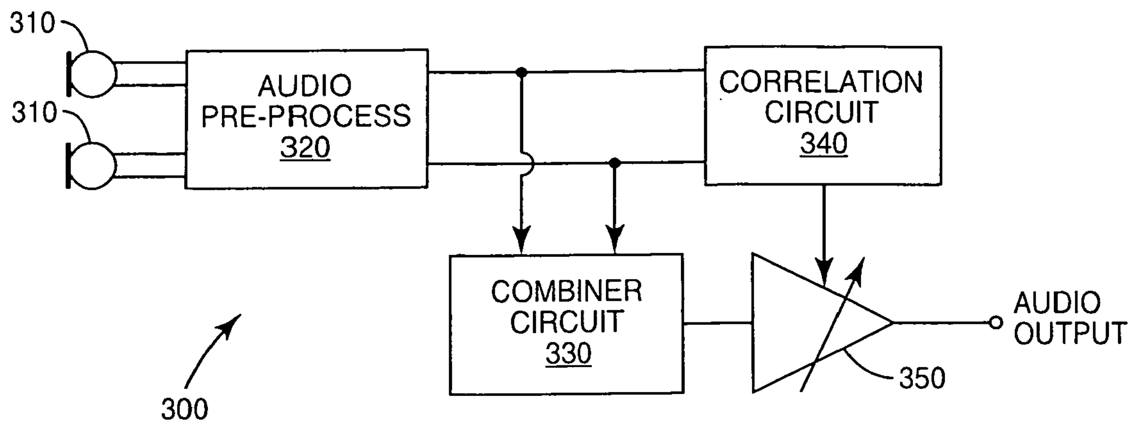
310
310
AUDIO
PRE-PROCESS
320
CORRELATION
CIRCUIT
340
COMBINER
CIRCUIT
330
AUDIO
OUTPUT
350
300

FIG. 3

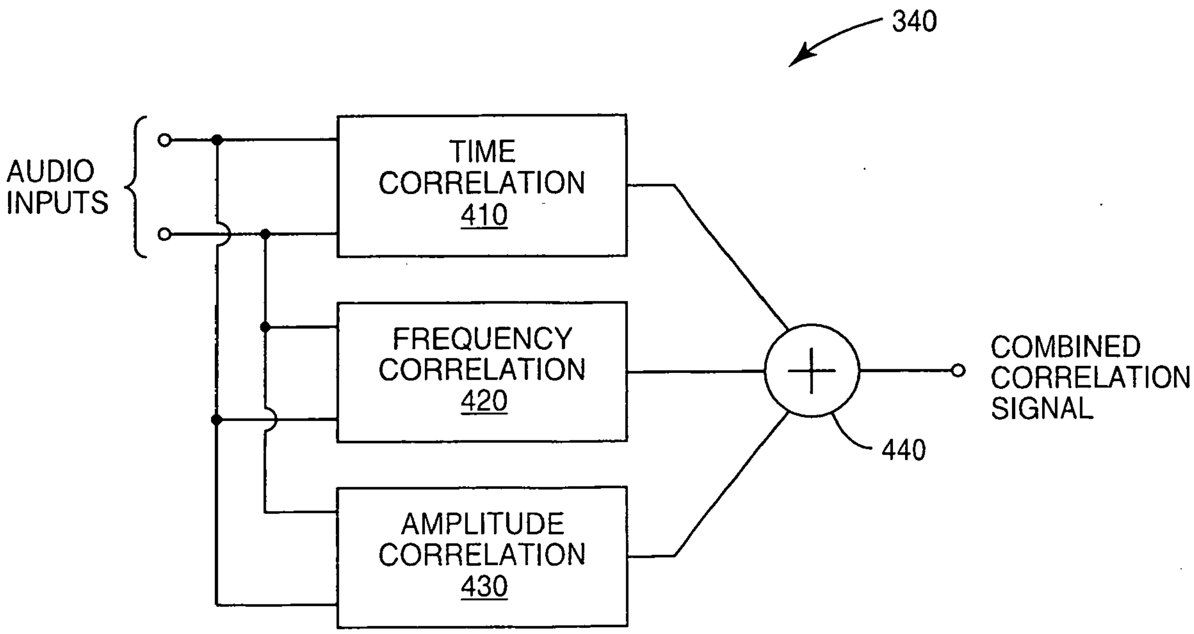
340
AUDIO
INPUTS
TIME
CORRELATION
410
FREQUENCY
CORRELATION
420
AMPLITUDE
CORRELATION
430
COMBINED
CORRELATION
SIGNAL
440

FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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