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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H04M 9/08, H04R 3/00

A1

(11) International Publication Number: WO 00/18099

(43) International Publication Date: 30 March 2000 (30.03.00)

(21) International Application Number: PCT/US99/21186

(22) International Filing Date: 14 September 1999 (14.09.99)

(30) Priority Data:
09/157,035 18 September 1998 (18.09.98) US

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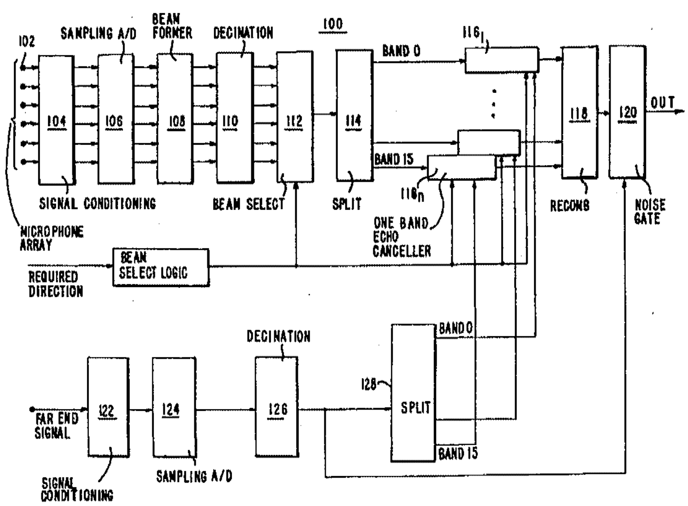
(81) Designated States: AU, CA, CN, IL, JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: INTERFERENCE CANCELING METHOD AND APPARATUS



(57) Abstract

Interference canceling is provided for canceling, from a target signal generated from a target source, an interference signal generated by an interference source. The beam splitter (114) beam–splits the target signal into a plurality of band–limited target signals band–limited frequency bands and beam–splits the interference signal into corresponding band–limited frequency bands. The adaptive filter (500) adaptively filters each band–limited interference signal from each corresponding band–limited target signal. The beam selector (112) selects beams simultaneously to improve accuracy and, in particular, selects a beam having a fixed direction and a beam which rotates in direction. The noise gate (120) gates the main signal adaptatively filtered by the adaptive filter by opening the noise gate (120) when a signal–to–noise ratio at the near–end is above a predetermined threshold and closing the noise gate when the signal–to–noise ratio at the near–end is below the predetermined threshold. When the target signal represents speech generated at a near end of a teleconference, the adaptive filter (500) cancels an echo present in the reference signal broadcast to a far end of the teleconference.

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TITLE OF THE INVENTION

INTERFERENCE CANCELING METHOD AND APPARATUS

RELATED APPLICATIONS

Reference is made to co-pending U.S. applications Serial Nos. 09/157,035, 08/672,899 (allowed), 09/130,923, 08/840,159, 09/059,503 and 09/055,709, each of which is hereby incorporated herein by reference; and each and every document cited in those applications, as well as each and every document cited herein, is hereby incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to an interference canceling method and apparatus and, for instance, to an echo canceling method and apparatus which provides echo-canceling in full duplex communication, especially teleconferencing communications.

BACKGROUND OF THE INVENTION

Tele-conferencing plays an extremely important role in communications today. The teleconference, particularly the telephone conference call, has become routine in business, in part because teleconferencing provides a convenient and inexpensive forum by which distant business interests communicate. Internet conferencing, which provides a personal forum by which the speakers can see one another, is enormously popular on the home front, in part because it brings together distant family and friends without the need for expensive travel.

In a teleconferencing system, the sounds present in a room, hereinafter referred to as the "near-end room" such as those of a near-end speaker are received by a microphone, transmitted to a "far end system" and broadcast by a far-end loudspeaker. Similarly, the far-end speaker is received by the far-end microphones and transmitted to the near-end system, and broadcast by the near-end loudspeaker. The near-end microphone receives the broadcasted sounds along with their reverberations and transmits them back to the far-end, together with the desired signals generated by, for example, speakers at the near-end, thereby resulting in a disturbing echo heard by the speaker at the far-end. The far-end speaker will hear himself after the sound has traveled to the near-end system and back, thereby resulting in a delayed echo which will annoy and confuse the far-end speaker. The problem is compounded in video and internet conferencing systems where the delay is more extremely pronounced.

The simplest way to overcome the problem of echo is by blocking the near-end microphone while the far-end signal is broadcast by the near-end loudspeaker. Sometimes referred to as "ducking", the technique of blocking the microphone is effectively a half-duplex communication. Problematically, if the microphone is blocked for a prolonged period to avoid transmission of the reverberations, the half-duplex communication becomes a significant drawback because the far-end speaker will lose too much of the near-end speaker. In the video or Internet conferencing system, where the delay created by the communication lines is extreme, ducking becomes quite annoying.

A more complex method to avoid echo is to employ an echo canceling system which measures the signals send from the far-end and broadcast at the near-end loudspeaker, estimates the resulting signal present at the near-end microphone (including the reverberations) and subtracts those signals representing the echo from the near-end microphone signals. The echo-free signals are then transmitted back to the far-end system.

In order to reduce the echo from the near-end microphone signal, it is required to obtain the transfer function that expresses the relationship between the near-end loudspeaker signal and the reverberations as they actually appear at the near-end microphone. This transfer function depends on the relative position of the near-end loudspeaker to the near-end microphone, the room structure, position of the system and even the presence of people in the room. Since it is impossible to predict these parameters *a priori*, it is preferred that the echo-canceling system updates the transfer function continuously in real time.

The adaptation process by which the echo-canceling system is updated in real time may be an LMS (least means square) adaptive filter (Widrow, et al., Proc. IEEE, vol. 63, pp. 1692-1716, Proc. IEEE, vol. 55, No. 12, Dec. 1967) with the far-end signal used as the reference signal. The LMS filter estimates the interference elements (echoes) present in the interfered channel by multiplying the reference channel by a filter and subtracting the estimated elements from the interfered signal. The resulting output is used for updating the filter coefficients. The adaptation process will converge when the resulting output energy is at a minimum, leaving an echo-free signal.

Important to the adaptation process is the selection of the size of the adaptation step of the filter coefficients. In the standard LMS algorithm the step size is controlled by a predetermined adaptation coefficient, the level of the reference channel and the output level. In other words, the adaptation process will have bigger steps for strong signals and smaller steps for weaker signals.

A better behaved system is one in which its adaptation steps are independent of the reference channel levels. This is accomplished by normalizing the adaptation coefficient by the reference channel energy, this method is called the

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