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(54) Benævnelse: **HØREAPPARAT MED ANTI-TILBAGEKOBLINGSSYSTEM**

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WO-A-01/06746
US-A1- 2001 002 930
US-A1- 2003 112 987

DESCRIPTION

AREA OF THE INVENTION

[0001] The invention relates to hearing aids and other audio equipment wherein feed back may occur when a captured audio signal is repeated by a loudspeaker (in hearing aids named the receiver) is recaptured by the microphone and further amplified.

BACKGROUND OF THE INVENTION

[0002] In hearing aids and other audio equipment it is often necessary to use anti feed back system in order to avoid the feed back problem. The anti feedback system may however be disturbed when changes occur in the signal path such as changes in directionality or changes in the choice of program effected either manually or automatically. The invention tries to avoid the problems which relate to correlation between anti feed back systems and fast changes in the signal processing in the signal path.

[0003] EP 1191814 A1 deals with an adaptive filter for suppression of acoustic feedback in a hearing aid. The hearing aid further comprises a controller that is adapted to compensate for acoustic feedback by determination of a first parameter of an acoustic feedback loop of the hearing aid and adjustment of a second parameter of the hearing aid in response to the first parameter whereby generation of undesired sounds is substantially avoided.

[0004] WO 01/06746 A2 deals with a method for cancelling feedback in an acoustic system, the method comprising providing an LMS algorithm for processing the signal, where the LMS algorithm operates with a predetermined adaptation speed when feedback is not present and where the LMS algorithm operates with an adaptation speed faster than the predetermined adaptation speed, when feedback is present, and where the means for detecting the presence of feedback is used to control the adaptation speed selection of the LMS algorithm.

SUMMARY OF THE INVENTION

[0005] The invention solves the problem that the hearing aid may start to howl when the directional processing changes mode or when other changes in the signal processing mode are provoked manually or by shifts in the environment.

[0006] According to the invention a hearing aid according to the subject-matter of claim 1 is provided.

[0007] The alert signal is used by the anti feed back system to change its mode, possibly such

that a faster adaptation will take place.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Figure 1. show a schematic representation of the hearing aid,

Figure 2. shows a diagram of the directional block,

Figure 3. is a diagram showing the function of the anti feedback block.

DESCRIPTION OF A PREFERRED EMBODIMENT

[0009] The hearing aid 1 according to the presented embodiment comprises a block for directional processing 2, a block for frequency shaping 3 and a block for anti feedback processing 4 configured according to Figure 1. The directional processing 2 can automatically switch between a directional mode, where signals with other incidents than frontal are attenuated, and an omni mode. The anti feedback system cancel the part of the input signal that is feedback and is used to allow for more gain without howl. As seen in fig. 2, the directionality block 2 generates two signals; a signal with directional sensitivity 11 and an omni signal 12. The output 13 of the block 2 will either be the one of these signals or a combination of the two. This is implemented with a fader 14 at the output of the block 2. The fader 14 applies gain to the two signals 11,12 before adding them. The gain applied to the omni-signal is called α_{omni} and have values in the range [0 1]. The gain applied to the signal with directional sensitivity 11 is (1- α_{omni}). α_{omni} is controlled by a controller 15 programmed to use the levels of the signals and estimation of signal to noise ratio in the input signal as well as possible other parameters to automatically choose the desired mode for the hearing aid user. The controller 15 can thus automatically change between the omni signal 12 and the directional signal 11. When changing mode, α_{omni} will gradually fade from 0 to 1, or vice versa.

[0010] The directional signal is preferably generated using an adaptive algorithm, but also stationary directional algorithms could be used.

[0011] The frequency shaping block 3 contains a filterbank and compressors for frequency shaping and dynamic compression, which is used to modify the signal to fit to the impaired hearing of the user. This block could also contain other types of signal processing to enhance the signal, e.g. noise reduction.

[0012] The anti feedback (AFB) block 4 generates an internal feedback path. The purpose of

this path is that it should have the same characteristics as the external feedback path via the receiver 20, acoustic paths 5, microphones 21, and directional block 2. If equal, the feedback caused by the external feedback paths 5 will be removed when *x(n),* the signal of the internal feedback, path is subtracted in the adder 16 after the directional block 2 in Figure 1.

[0013] The AFB uses an adaptive algorithm to track the changes of the external feedback path. A parameterized model of the feedback is used where the parameters are the coefficients of the FIR-filter. The adaptive algorithm is based on a prediction error method, that adjusts the coefficients so that the energy in the residual signal after cancellation, *e(n)*, is minimized.

[0014] The coefficients are updated with a step given by and adaptive algorithm with a predefined step size μ_0. Possibly a normalized least mean square (NLMS) algorithm as described in the following is used. This gives a step in the direction of steepest descent for the energy of e(n). The update is given by

$$\theta(n) = \theta(n-1) + 2\frac{\mu_0}{\beta + \psi(n)'\psi(n)}\psi(n)e(n)$$

where $\theta(n)$ is a vector with the coefficients, $\psi(n)$ is a vector of same length as $\theta(n)$ with the last samples of $u(n)$, and μ_0 is a scalar that defines the step size. μ_0 will control how fast the adaptive filter can adapt to changes in the external feedback path.

[0015] One shortcoming of the adaptive filter is that it may adapt to tonal components of the input signal. The tonal component may then be attenuated. To reduce the sensitivity to tonal components a small μ_0 (i.e. slow adaptation) can be used. However, the adaptation speed acquired with this μ_0 will usually be too slow if the hearing aid becomes unstable and starts to howl.

[0016] Two alternative values of μ_0 are used, one low value for slow adaptation to get good resistance to tonal components and a higher value to get fast adaptation when required. However, the μ_0 is programmable, and a range of different values could be used if it is desired.The fast adaptation is used when the tone detector has detected howl. A hysteresis is used to allow for fast adaptation in a predefined period after the howl has vanished.

[0017] The external feedback paths 5 that the AFB tries to track is dependent on the DIR-block 2. The feedback path can change substantially when switching between omni mode and directional mode. The AFB will then be misadjusted if the adaptation speed is too slow compared to the transition time of α_{omni}. As a result the hearing aid may start to howl at the automatic transitions between the omni signal and directional signal.

[0018] According to the invention the AFB system is forced to use fast mode when the directionality changes from omni mode to directional mode and thus prevents the hearing aid from howling due to too slow adaptation. The gain α_{omni} is used to monitor when changes occur. Values in the middle of the range from 0 to 1 will cause adaptation with the fast mode.

The trigger 17 of Figure 1 gives an output (*dir_shift*) 18 of 1 when the input, α_{omni}, is in the specified range. Other values of α_{omni} will give an output of 0. The signal *dir_shift* 18 is in the AFB-block combined with the output of the tone detector in an OR-gate, so either of them can cause fast mode. The hysteresis insures that fast mode is used during the last part of the transition when α_{omni} has left the specified range.

[0019] Other changes of the processing such as manual or automatic program shifts may also be used to control the adaptation speed of the antifeedback algorithm. Here it should be mentioned that any change involving changes in the gain setting could be used to set the adaptation speed of the anti feedback algorithm. This could be changes in soft squelch, compression or noise damping. Also in systems with adaptive directionality as described above the change in directionality, which might take place in one or more bands could also be used as input to the changes of the adaptation speed of the anti-feedback algorithm.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP1191814A1 **[0003]**
- WO0106746A2 **[0004]**

P-2004-004DK
EP 1 730 992

HØREAPPARAT MED ANTI-TILBAGEKOBLINGSSYSTEM

Patentkrav

1. Høreapparat (1) med et anti-tilbagekoblingssystem (4) til estimering af en ekstern tilbagekoblingsvej (5), hvor anti-tilbagekoblingssystemet er indrettet til at fungere i en af i det mindste to tilpasningsmodusser, en hurtig tilpasningsmodus og en langsom tilpasningsmodus, og omfattende:

• en signalvej fra to eller flere mikrofoner (21) til en udgangstransducer (20),

• en signalbehandlingsenhed (3),

kendetegnet ved, at den yderligere omfatter:

• en retningsbestemt behandlingsblok (2), der modtager indgangssignaler fra de nævnte to eller flere mikrofoner (21) og frembringer et DIR-signal (11) med retningsbestemt følsomhed og et OMNI-retningsbestemt signal (12) og tilvejebringer et udgangssignal (y) til behandling i signalvejen i form af enten et af de to DIR- og OMNI-signaler eller en kombination af de to DIR- og OMNI- signaler i afhængighed af forstærkningsfaktorer, der er anvendt til de to signaler, før de tilføres, hvor forstærkningsfaktoren (α_{omni}), der er anvendt til det OMNI-retningsbestemte signal, har værdier i området [0, 1], og hvor forstærkningsfaktoren, der er anvendt til DIR-signalet, er ($1-\alpha_{omni}$),

• akustisk omgivelsesdetekteringsmiddel, der anvender parametre for indgangssignalet, til automatisk angivelse af en ændring mellem det OMNI-retningsbestemte signal og DIR-signalet,

• triggermiddel (17), der er indrettet til at frembringe et alarmsignal (dir_shift) til anti-tilbagekoblingssystemet (4), hvor alarmsignalet angiver tilpasningsmodussen til anti-tilbagekoblingssystemet (4), som er baseret på værdien af forstærkningsfaktoren (α_{omni}), og

• styremiddel (15), der er indrettet til at frembringe en værdi for forstærkningsfaktoren (α_{omni}), som er baseret på enten manuelt input eller output fra det akustiske omgivelsesdetekteringsmiddel og anvendes som et input til triggermidlet (17) og antyder, hvornår den retningsbestemte behandling ændres mellem at tilvejebringe det OMNI-retningsbestemte signal og DIR-signalet.

2. Høreapparat ifølge krav 1, hvor alarmsignalet anvendes af anti-tilbagekoblingssystemet for at ændre modussen, så at en hurtigere tilpasning vil finde sted.

3. Høreapparat ifølge krav 1, hvor α_{omni} gradvist vil fortage sig fra 0 til 1, eller vice versa, når den retningsbestemte behandlingsblok ændrer modus.

4. Høreapparat ifølge krav 1, hvor værdierne af $\alpha_{omni,}$ midten af området fra 0

til 1, vil medføre tilpasning af anti-tilbagekoblingssystemet med den hurtigere tilpasningsmodus.

5. Høreapparat ifølge krav 1, hvor anti-tilbagekoblingssystemet anvender en adaptiv algoritme til at spore ændringerne ved den eksterne tilbagekoblingsvej.

6. Høreapparat ifølge krav 5, hvor anti-tilbagekoblingssystemet, der omfatter et FIR filter og en parametriseret model af tilbagekoblingen, anvendes, hvor parametrene er koefficienterne af FIR-filtret.

7. Høreapparat ifølge krav 6, hvor den adaptive algoritme er baseret på en forudsigelsesfejlfremgangsmåde, der tilpasser koefficienterne, så at energien i restsignalet efter annullering minimeres, og hvor koefficienterne er opdateret med et trin, der er givet af en adaptiv algoritme med en foruddefineret trinstørrelse μo, hvor μo styrer, hvor hurtigt det adaptive filter kan tilpasse sig ændringer i den eksterne tilbagekoblingsvej.

8. Høreapparat ifølge krav 7, hvor trinstørrelsen er programmerbar.

9. Høreapparat ifølge krav 7, hvor to alternative værdier af μo anvendes, en lille værdi til langsom tilpasning og en højere værdi til hurtigere tilpasning af det adaptive filter.

10. Høreapparat ifølge krav 1, hvor anti-tilbagekoblingssystemet omfatter en tonedetektor til at detektere hylen, og hvor den hurtigere tilpasning af det adaptive filter anvendes, når tonedetektoren har detekteret hylen.

11. Høreapparat ifølge krav 10, hvor en hysterese anvendes til at muliggøre hurtig tilpasning i en foruddefineret periode efter hylene er forsvundet eller efter en overgang i α_{omni}

12. Høreapparat ifølge krav 1, hvor den retningsbestemte behandlingsblok danner en del af den eksterne tilbagekoblingsvej, der er estimeret af anti-tilbagekoblingssystemet.

DRAWINGS

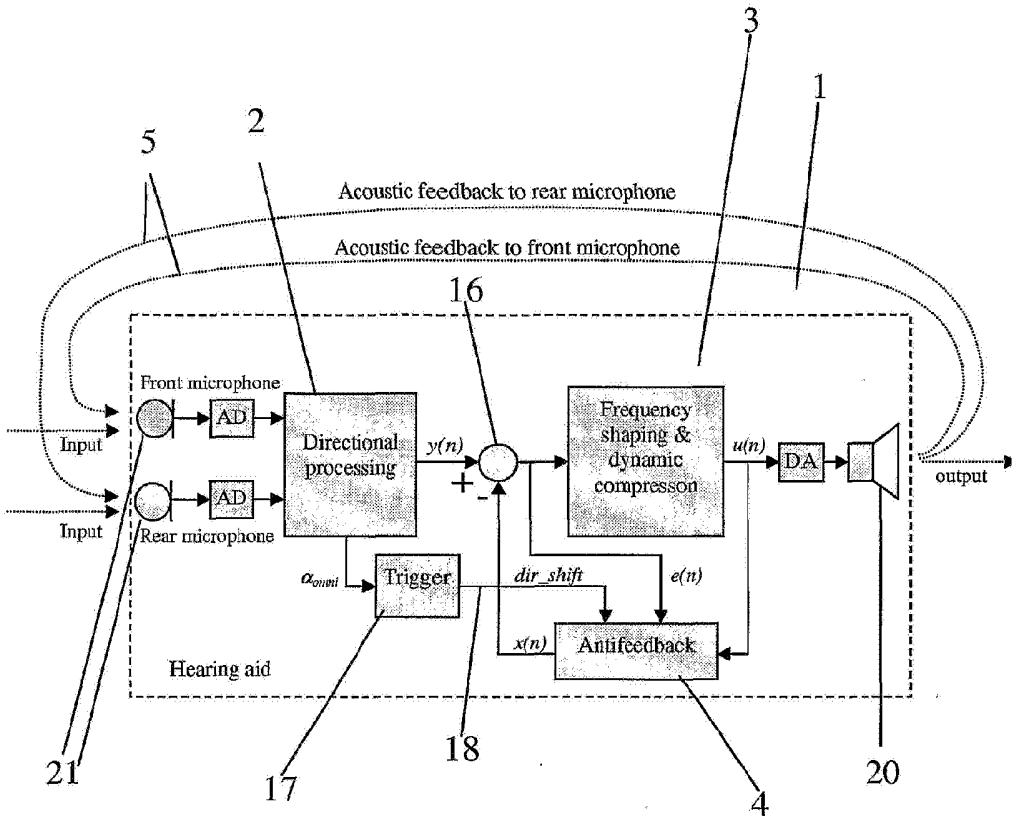

Fig. 1

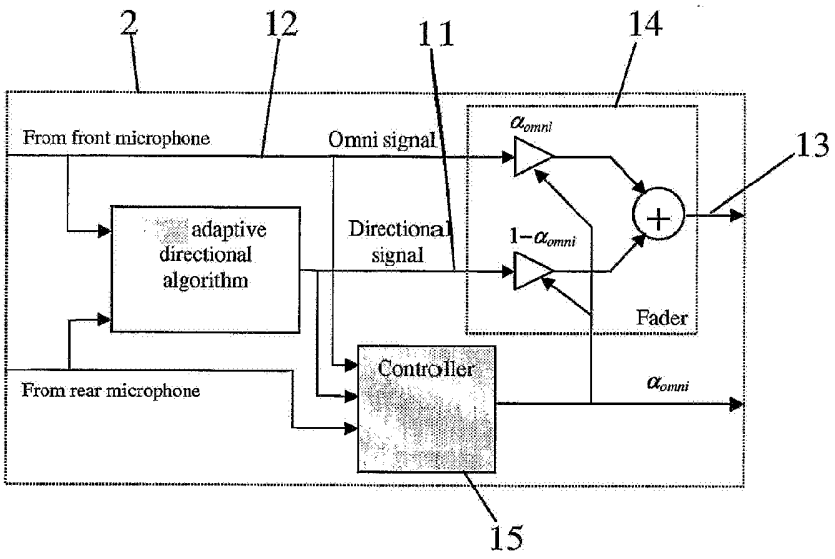
2
12
11
14
13
From front microphone
Omni signal
α_{omni}
adaptive directional algorithm
Directional signal
$1-\alpha_{omni}$
Fader
Controller
From rear microphone
α_{omni}
15

Fig. 2

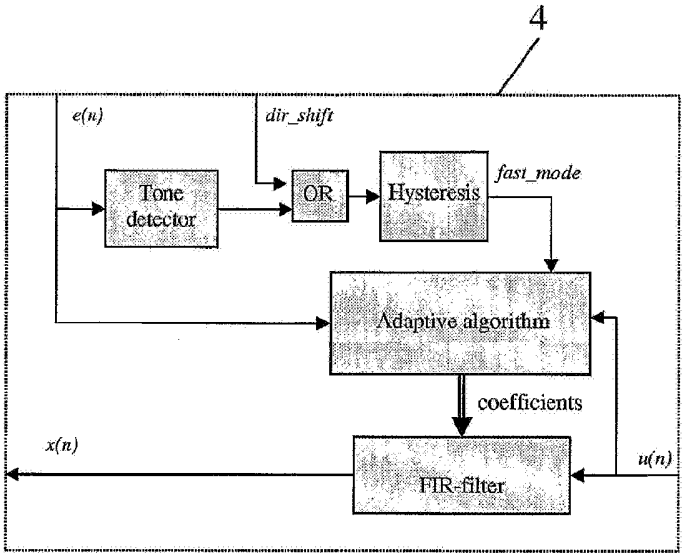
4
e(n)
dir_shift
Tone detector
OR
Hysteresis
fast_mode
Adaptive algorithm
coefficients
x(n)
FIR-filter
u(n)

Fig. 3