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(54) **SIGNAL PROCESSING DEVICE, PROGRAM, AND RANGE HOOD SYSTEM**

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(Continued)

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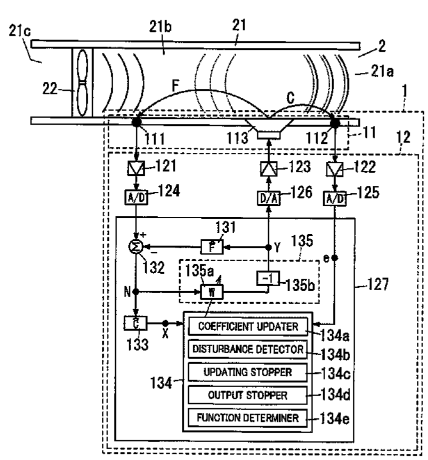
(57) **ABSTRACT**

A silencer is to be used in combination with a range hood system to suppress noise made by a fan. In a silencing circuit, a disturbance detector detects mixing of disturbance sound to a correction signal and an error signal. When the disturbance detector detects the mixing of the disturbance sound, an updating stopper causes a coefficient updater to stop a processing of updating a filter coefficient of a silencer filter, relating to, as an object, at least a frequency band other than a frequency band of the noise.

11 Claims, 5 Drawing Sheets



(52) **U.S. Cl.**
CPC ***F24F 13/24*** (2013.01); ***G10K 11/178*** (2013.01); *F24F 2013/247* (2013.01); *G10K 2210/105* (2013.01); *G10K 2210/109* (2013.01); *G10K 2210/112* (2013.01); *G10K 2210/3025* (2013.01); *G10K 2210/3026* (2013.01); *G10K 2210/3028* (2013.01); *G10K 2210/30231* (2013.01)

(58) **Field of Classification Search**
USPC 381/71.5, 71.6, 71.1, 71.8, 71.9, 71.12, 381/61, 56, 63
See application file for complete search history.

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FIG. 1

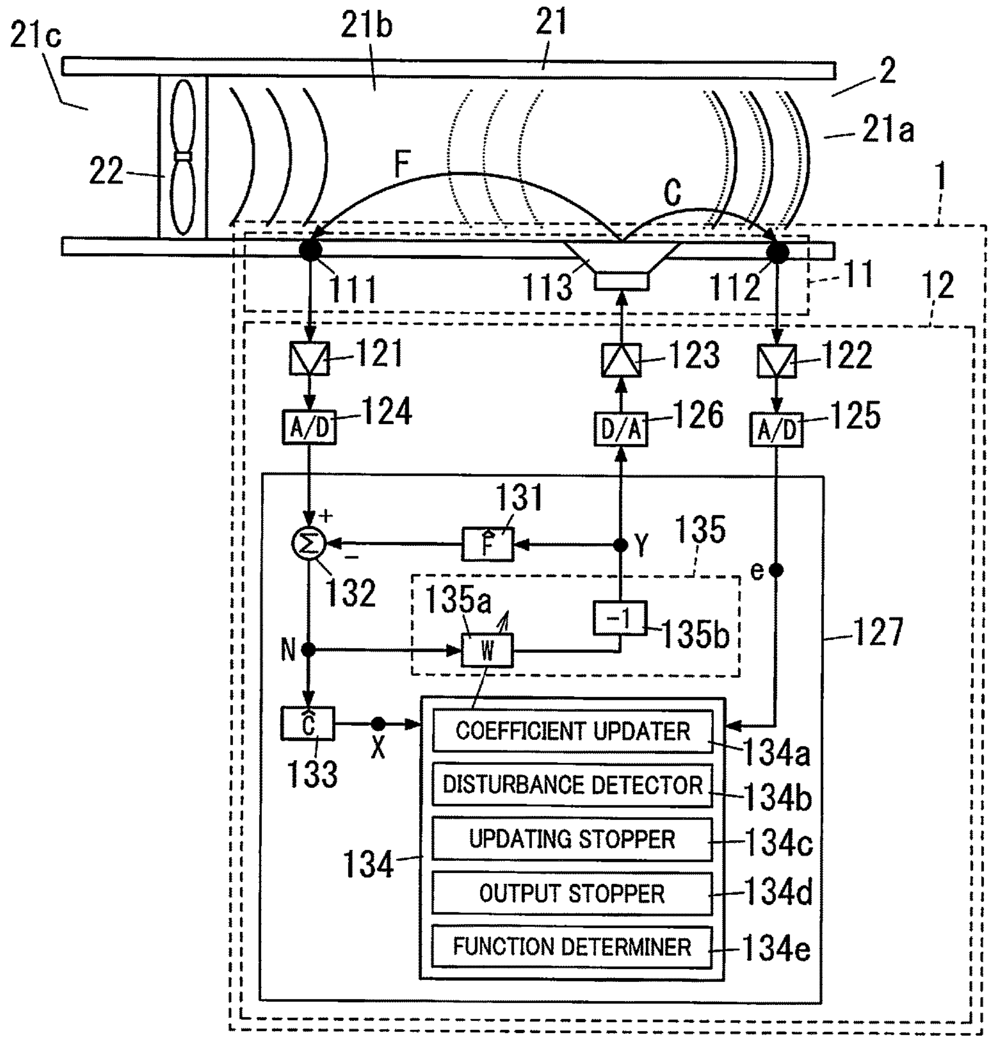

21c
21b
21
2
21a
22
F
C
1
111
113
112
11
12
121
123
122
A/D
124
D/A
126
A/D
125
131
F̂
Y
135
e
132
135a
W
−1
135b
127
N
Ĉ
X
COEFFICIENT UPDATER
134a
DISTURBANCE DETECTOR
134b
133
UPDATING STOPPER
134c
134
OUTPUT STOPPER
134d
FUNCTION DETERMINER
134e

FIG. 2

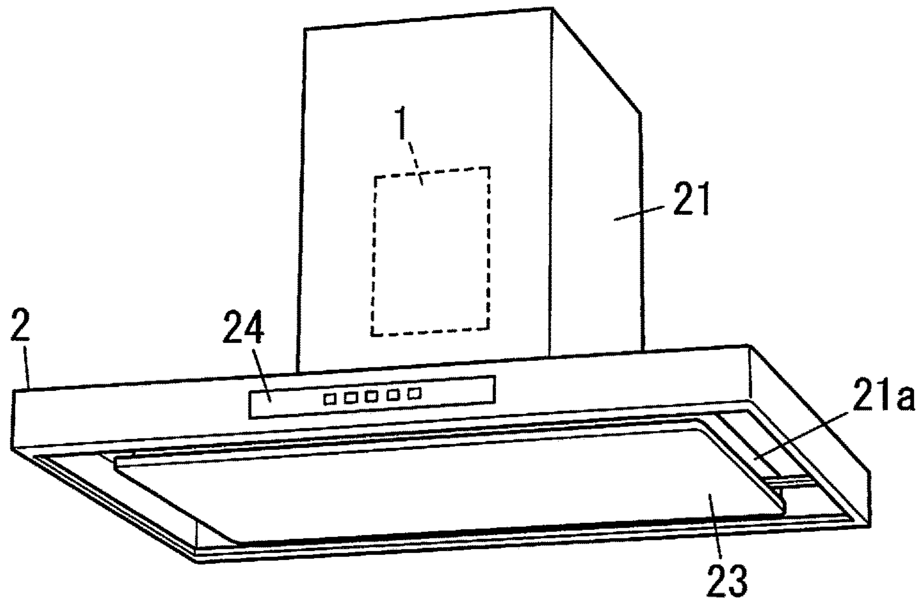


FIG. 3

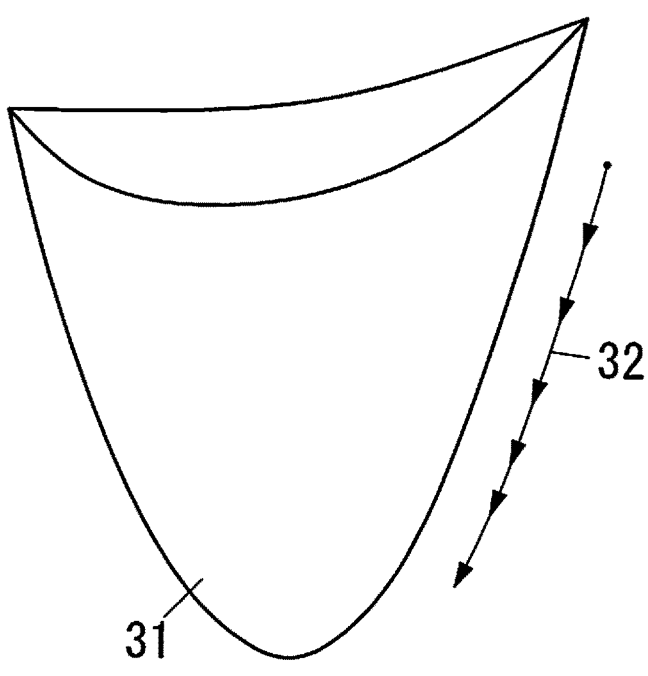


FIG. 4

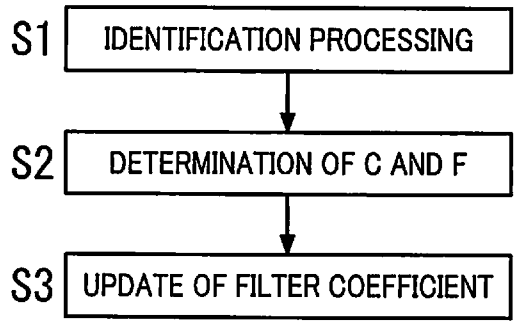

S1
IDENTIFICATION PROCESSING
S2
DETERMINATION OF C AND F
S3
UPDATE OF FILTER COEFFICIENT

FIG. 5

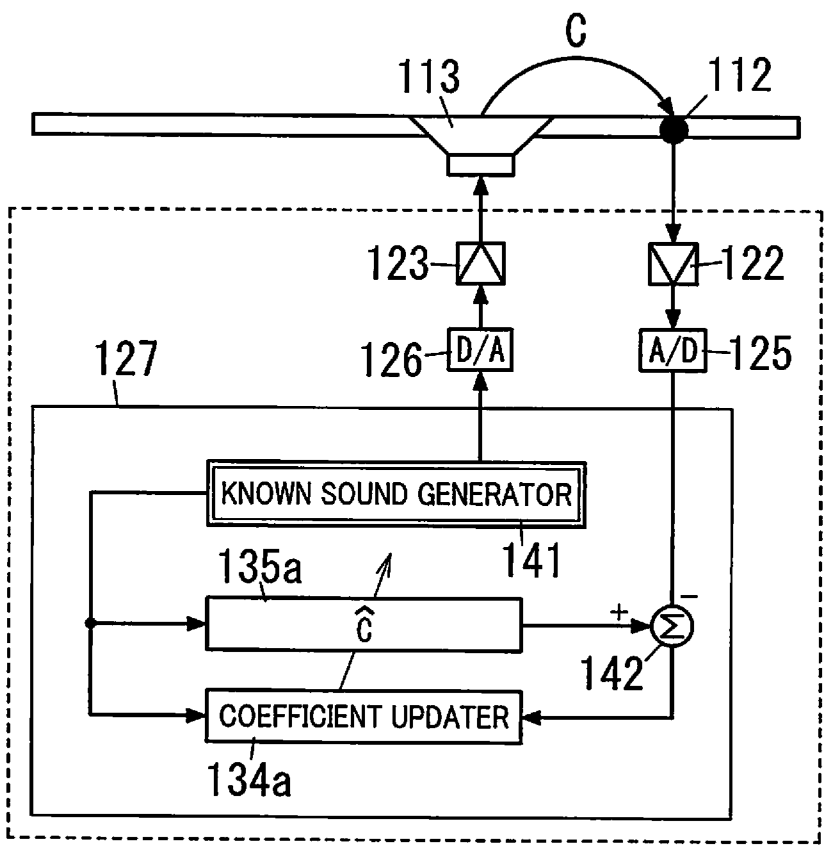

C
113
112
123
122
127
126
D/A
A/D
125
KNOWN SOUND GENERATOR
141
135a
Ĉ
+
−
Σ
142
COEFFICIENT UPDATER
134a

FIG. 6

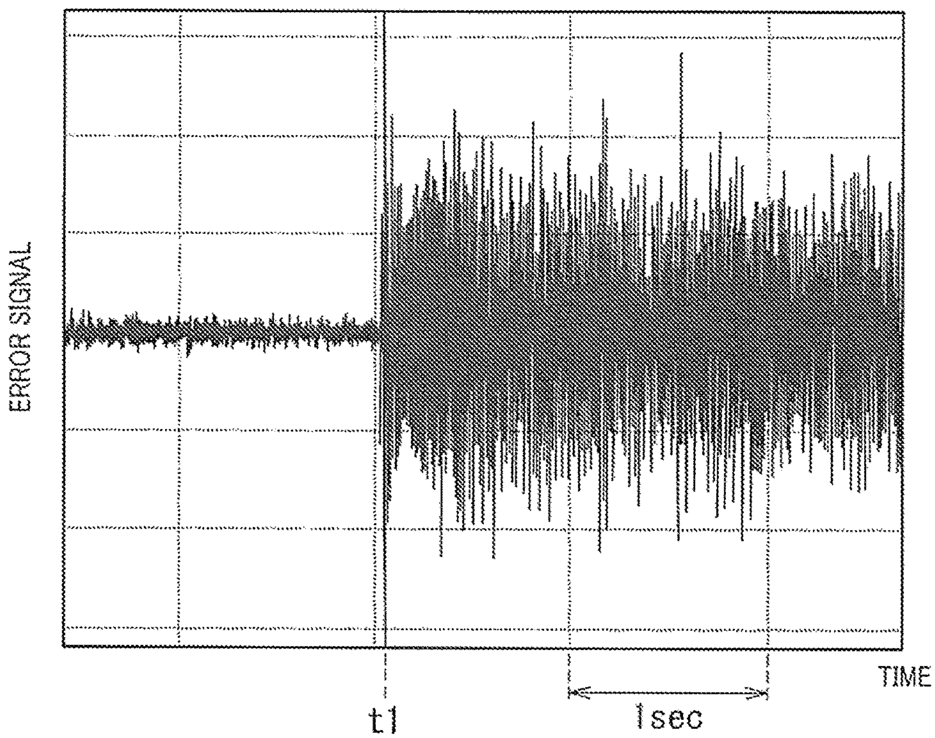


FIG. 7

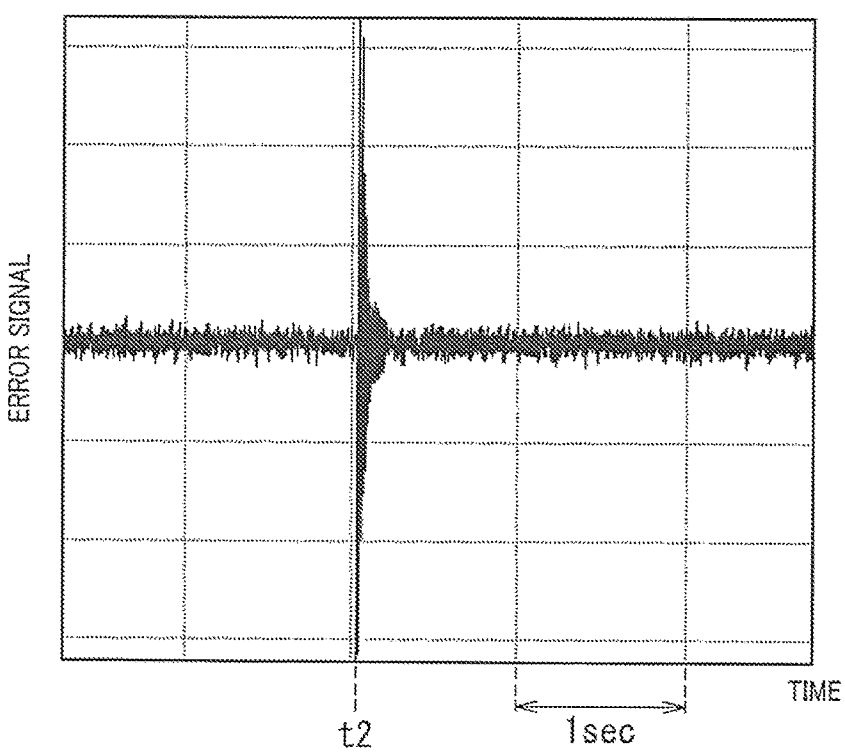


FIG. 8

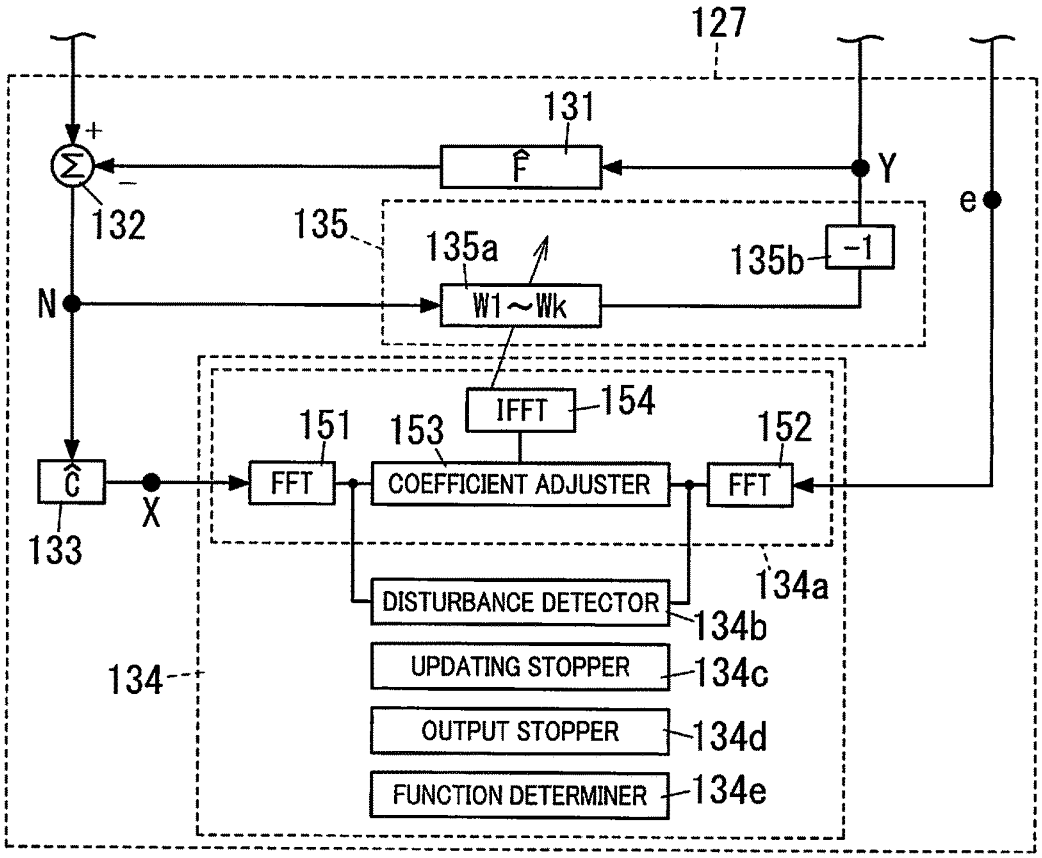
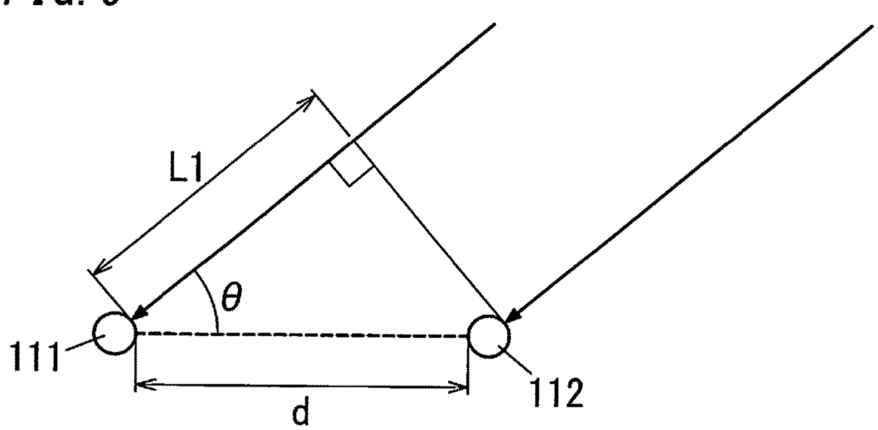

127
131
F̂
Y
e
+
Σ
−
132
135
135a
135b
−1
N
W1～Wk
IFFT
154
151
153
152
Ĉ
FFT
COEFFICIENT ADJUSTER
FFT
X
133
134a
DISTURBANCE DETECTOR
134b
UPDATING STOPPER
134c
134
OUTPUT STOPPER
134d
FUNCTION DETERMINER
134e

FIG. 9


L1
θ
111
112
d

SIGNAL PROCESSING DEVICE, PROGRAM, AND RANGE HOOD SYSTEM

TECHNICAL FIELD

This invention relates generally to signal processing devices, programs, and range hood systems and, more particularly, to a signal processing device, a program and a range hood system, which utilize active noise control.

BACKGROUND ART

There has been conventionally a silencer using active noise control, as a technique for reducing noise in an object space where sound made by a noise source is propagated (a noise propagation path). The active noise control is a technique to actively reduce the noise by emitting a canceling sound with the reverse phase and the same amplitude relative to the noise.

The active noise control is to execute a silencing program that realizes a function of an adaptive filter in order to follow up a change in the noise made by the noise source or a change in the noise propagation characteristics. However, in case there is external sound (disturbance sound) other than the noise, which is the sound to be silenced, made by the noise source, the disturbance sound may cause a filter coefficient of the adaptive filter to diverge. As a result of divergence of the filter coefficient, an effect of canceling the noise may be reduced, and further, the canceling sound itself emitted by the silencer may become noise.

To solve this issue, there has been proposed a silencer that, when abnormity such as the disturbance sound is detected, resets parameters such as a transfer function and a convergence coefficient which are to be used for the active noise control, and stops outputting of the canceling sound when the number of abnormity detection times exceeds a prescribed value (refer to Document 1: JP 1998-187201 A).

Document 1 discloses the technique, when the disturbance sound is detected, to continue the processing of updating the filter coefficient while resetting the parameters such as the transfer function and the convergence coefficient to be used for the active noise control. As a result, the filter coefficient may diverge, depending on the disturbance sound, even when the parameters such as the transfer function and the convergence coefficient are reset while the update processing of the filter coefficient is continued. In addition, even though the filter coefficient does not diverge, the filter coefficient may be updated to a value adaptive to the disturbance sound that is not the sound to be silenced, and accordingly, it may cause to reduce the performance of silencing the noise, which is originally the sound to be silenced, for some time after the mixing of the disturbance sound has been lost.

SUMMARY OF INVENTION

It is an object of the present invention to provide a signal processing device, a program and a range hood system, which can suppress divergence of a filter coefficient, and a reduction in silencing performance caused by adaptation to disturbance sound, even when the disturbance sound is collected in active noise control.

A signal processing device according to an aspect of the present invention is to be used in combination with a sound input/output device. The sound input/output device includes a first sound inputter, a sound outputter and a second sound inputter. The first sound inputter is installed in an object space, where noise made by a noise source is propagated, to collect the noise. The sound outputter is configured to output a canceling sound for canceling the noise to the object space in response to receiving a canceling signal. The second sound inputter is configured to collect a synthesized sound of the noise and the canceling sound in the object space. The signal processing device includes a canceling signal generator, a correction filter, a coefficient updater, a disturbance detector and an updating stopper. The canceling signal generator includes a silencer filter with a filter coefficient, and is configured to output the canceling signal in response to receiving a first signal generated based on an output of the first sound inputter. The correction filter is configured to generate a second signal by correcting the first signal based on a transfer function of an acoustic path from the sound outputter to the second sound inputter. The coefficient updater is configured to calculate the filter coefficient based on the second signal and a third signal generated from an output of the second sound inputter, and update the filter coefficient of the silencer filter. The disturbance detector is configured to detect mixing of disturbance sound, different from each of the noise and the canceling sound, to at least one of the output of the first sound inputter and the output of the second sound inputter. The updating stopper is configured to, when the disturbance detector detects the mixing of the disturbance sound, cause the coefficient updater to stop a processing of updating the filter coefficient, relating to at least a frequency band other than a frequency band of the noise.

A program according to an aspect of the present invention is to be stored in a computer that is used in combination with a sound input/output device. The sound input/output device includes a first sound inputter, a sound outputter and a second sound inputter. The first sound inputter is installed in an object space, where noise made by a noise source is propagated, to collect the noise. The sound outputter is configured to output a canceling sound for canceling the noise to the object space in response to receiving a canceling signal. The second sound inputter is configured to collect a synthesized sound of the noise and the canceling sound in the object space. The program causes the computer to realize: a function to constitute a silencer filter with a filter coefficient, and output the canceling signal in response to receiving a first signal generated based on an output of the first sound inputter; a function to generate a second signal by correcting the first signal based on a transfer function of an acoustic path from the sound outputter to the second sound inputter; a function to calculate the filter coefficient based on the second signal and a third signal generated from an output of the second sound inputter, and update the filter coefficient of the silencer filter; a function to detect mixing of disturbance sound, different from each of the noise and the canceling sound, to at least one of the output of the first sound inputter and the output of the second sound inputter; and a function to, when the mixing of the disturbance sound is detected, stop a processing of updating the filter coefficient, relating to at least a frequency band other than a frequency band of the noise. Note that, a medium that provides the program may be a computer-readable recording medium.

A range hood system according to an aspect of the present invention includes a ventilation passage, an air blower, a first sound inputter, a sound outputter, a second sound inputter and a signal processing device. The ventilation passage has a hollow tubular shape. The air blower is configured to generate air flow from a first end of the ventilation passage to a second end of the ventilation passage. The first sound inputter is installed in the ventilation passage to collect noise made by the air blower. The sound outputter is configured to output a canceling sound for canceling the noise to the ventilation passage in response to receiving a canceling signal. The second sound inputter is configured to collect a synthesized sound of the noise and the canceling sound in the ventilation passage. The signal processing device is configured to generate the canceling signal. The signal processing device includes a canceling signal generator, a correction filter, a coefficient updater, a disturbance detector and an updating stopper. The canceling signal generator includes a silencer filter with a filter coefficient, and is configured to output the canceling signal in response to receiving a first signal generated based on an output of the first sound inputter. The correction filter is configured to generate a second signal by correcting the first signal based on a transfer function of an acoustic path from the sound outputter to the second sound inputter. The coefficient updater is configured to calculate the filter coefficient based on the second signal and a third signal generated from an output of the second sound inputter, and update the filter coefficient of the silencer filter. The disturbance detector is configured to detect mixing of disturbance sound, different from each of the noise and the canceling sound, to at least one of the output of the first sound inputter and the output of the second sound inputter. The updating stopper is configured to, when the disturbance detector detects the mixing of the disturbance sound, cause the coefficient updater to stop a processing of updating the filter coefficient, relating to at least a frequency band other than a frequency band of the noise.

In the signal processing device, the program and the range hood system according to the aspects of the present invention, when the mixing of the disturbance sound is detected, the processing of updating the filter coefficient of the silencer filter is stopped, as described above. Therefore, when the mixing of the disturbance sound is detected, the silencer filter maintains the filter coefficient that has been set before the occurrence of the disturbance sound, and it is accordingly possible to suppress divergence of the filter coefficient, and a reduction in the silencing performance caused by adaptation to the disturbance sound. That is, an effect is provided in which, even when the disturbance sound is collected in active noise control, it is possible to suppress divergence of the filter coefficient, and a reduction in the silencing performance caused by adaptation to the disturbance sound.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram illustrating an exemplary configuration of a range hood system according to Embodiment 1;

FIG. **2** is a perspective view of an appearance of the range hood system according to Embodiment 1;

FIG. **3** is an explanatory diagram illustrating an error curved surface of a steepest descent algorithm according to Embodiment 1;

FIG. **4** is a flowchart illustrating a relationship between an identification processing and an update processing according to Embodiment 1;

FIG. **5** is a schematic block diagram illustrating an identification processing for a transfer function according to Embodiment 1;

FIG. **6** is a waveform diagram illustrating a silencing effect in case a disturbance detector is not made operated, according to Embodiment 1;

FIG. **7** is a waveform diagram illustrating a silencing effect in case the disturbance detector is made operated, according to Embodiment 1;

FIG. **8** is a block diagram illustrating part of a configuration according to Embodiment 2; and

FIG. **9** is an explanatory diagram illustrating a processing of a disturbance detector according to Embodiment 3.

DESCRIPTION OF EMBODIMENTS

(Embodiment 1)

FIG. **1** shows an exemplary configuration of a range hood system **2** into which a silencer **1** (active noise control device) is incorporated.

The range hood system **2**, as shown in FIG. **2**, includes a hood **21** (ventilation passage) disposed above a kitchen utensil in a kitchen. The hood **21** has a box-shape, and is provided in a bottom surface thereof with an intake port **21***a*. The hood **21** includes therein a fan **22** (refer to FIG. **1**) for taking the indoor air into the hood **21** from the indoor through the intake port **21***a*, and exhausting the indoor air to the outdoor. In other words, a space within the hood **21** corresponds to the ventilation passage, and the fan **22** generates in the ventilation passage air flow from the intake port **21***a* of the hood **21** to an exhaust port **21***c* (refer to FIG. **1**).

The range hood system **2** further includes a straightening plate **23**. The intake port **21***a* is formed around the straightening plate **23**. The straightening plate **23** has a function to improve intake efficiency. The range hood system **2** is provided at a front surface thereof with an operation portion **24**. The operation portion **24** includes operational switches for various operations of the range hood system **2**, an indication lamp for indicating an operation state, and the like.

While the fan **22** is operating, the operation sound of the fan **22** is propagated in the ventilation passage, and then transmitted into the indoor through the intake port **21***a*. That is, the fan **22** is a noise source, and the noise is propagated into the indoor through the space within the hood **21**. In other words, execution of silencing in the space within the hood **21** can reduce the noise that is propagated from the noise source to the intake port **21***a*. In this embodiment, the silencer **1** is installed in order to suppress the noise from being transmitted into the indoor while the fan **22** is operating. Hereinafter, the space within the hood **21**, which is an object to be silenced, is referred to as an "object space". The object space is denoted by a reference sign "**21***b*".

The silencer **1**, as shown in FIG. **1**, includes an sound input/output device **11** and a silencing circuit **12**.

The sound input/output device **11** includes a referring microphone **111** (first sound inputter), an error microphone **112** (second sound inputter), and a speaker **113** (sound outputter). The referring microphone **111** is disposed on the side of the fan **22** in the hood **21**. The error microphone **112** is disposed on the side of the intake port **21***a* in the hood **21**. The speaker **113** is disposed between the referring microphone **111** and the error microphone **112** in the object space **21***b*. That is, the referring microphone **111**, the speaker **113** and the error microphone **112** are arranged in that order in a path from the fan **22** as the noise source to the intake port **21***a*.

The silencing circuit **12** includes amplifiers **121**, **122** and **123**, A/D converters **124** and **125**, a D/A converter **126** and a signal processing device **127**.

An analog signal output from the referring microphone **111** is amplified by the amplifier **121**, and then subjected to an Analog-Digital conversion by the A/D converter **124**. A digital signal output from the A/D converter **124** is input to the signal processing device **127**. On the other hand, an analog signal output from the error microphone **112** is amplified by the amplifier **122**, and then subjected to an Analog-Digital conversion by the A/D converter **125**. A digital signal output from the A/D converter **125** is input to the signal processing device **127**.

The signal processing device **127** is configured by a computer that executes a program. The signal processing device **127** defines to a "silencing point" a position where the error microphone **112** is disposed, and causes the speaker **113** to output a canceling sound for canceling the noise made by the fan **22** such that a sound pressure level at the silencing point is minimized. That is, the signal processing device **127** outputs a canceling signal that is a digital signal. This canceling signal is subjected to a Digital-Analog conversion by the D/A converter **126**, and then amplified by the amplifier **123**. The speaker **113** is then driven by the canceling signal that is an analog signal output from the amplifier **123**, and accordingly outputs a canceling sound.

The speaker **113** outputs the canceling sound, thereby suppressing the noise that transmits from the fan **22** to the outside of the hood **21** through the intake port **21***a*. The signal processing device **127** performs active noise control, and has a function of an adaptive filter in order to follow up a change in the noise made by the fan **22** as the noise source or a change in the noise propagation characteristics.

The signal processing device **127** includes a device of operating according to a program, which may be selected from DSP (Digital Signal Processor), CPU (Central Processing Unit), MPU (Micro-Processing Unit) and the like. A filter coefficient of the adaptive filter is updated using a sequential update control algorithm referred to as Filtered-X LMS (Least Mean Square).

Hereinafter, operation of the silencing circuit **12** will be described.

The referring microphone **111** outputs a reference signal, obtained by converting sound including the noise made by the fan **22** into an electrical signal. The signal processing device **127** receives the reference signal, which is a digital signal, through the amplifier **121** and the A/D converter **124**. Here the A/D converter **124** performs an Analog-Digital conversion with a predetermined sampling frequency to the reference signal amplified by the amplifier **121**, and outputs the reference signal, which is a digital signal, to the signal processing device **127**.

The error microphone **112** outputs an error signal obtained by converting, into an electrical signal, sound including residual noise, which is remained without being canceled at the silencing point by the canceling sound. The signal processing device **127** receives the error signal e, which is a digital signal, through the amplifier **122** and the A/D converter **125**. Here the A/D converter **125** performs an Analog-Digital conversion with the same sampling frequency as the A/D converter **124** to the error signal amplified by the amplifier **122**, and outputs the error signal e (third signal), which is a digital signal, to the signal processing device **127**.

The signal processing device **127** includes a howling cancel filter **131**, a subtractor **132**, a correction filter **133**, a controller **134** and a canceling signal generator **135**. The controller **134** includes a coefficient updater **134***a*, a disturbance detector **134***b*, an updating stopper **134***c*, an output stopper **134***d* and a function determiner **134***e*. The canceling signal generator **135** includes a silencer filter **135***a* and a phase inverter **135***b*.

The howling cancel filter **131** is a FIR (Finite Impulse Response) filter in which a transfer function F^ is set as a filter coefficient. The transfer function F^ is obtained by simulating a transfer function F of a sound wave from the speaker **113** to the referring microphone **111**. In this embodiment, a sign with the symbol "^" (i.e., ^ symbol) (for example, a sign "F^" with respect to a sign "F") corresponds to a sign having a hat symbol thereabove, shown in the figures. A sign having the hat symbol represents a transfer function obtained by simulating a transfer function represented by a sign not having the hat symbol. For example, a sign "F^" represents a transfer function obtained by simulating a transfer function F.

The howling cancel filter **131** subjects the canceling signal Y output from the canceling signal generator **135** and the transfer function F^ to convolution calculation. The subtractor **132** outputs a signal obtained by subtracting an output of the howling cancel filter **131** from the reference signal, output from the A/D converter **124**. That is, the subtractor **132** subtracts a wraparound component of the canceling sound from the noise signal, output from the referring microphone **111**, and accordingly, outputs a noise signal N (first signal) obtained by extracting a noise component made by the fan **22**. By this processing, it is possible to prevent occurrence of howling, even if the canceling sound emitted from the speaker **113** sneaks to the referring microphone **111**. The noise signal N from the subtractor **132** is input to both of the correction filter **133** and the silencer filter **135***a* of the canceling signal generator **135**.

The correction filter **133** and the silencer filter **135***a* are a FIR type of adaptive filter. A filter coefficient of the correction filter **133** is set so as to be identical to a transfer function C^ obtained by simulating a transfer function C of a sound wave from the speaker **113** to the error microphone **112**. The correction filter **133** subjects the noise signal N output from the subtractor **132** and the transfer function C^ to convolution calculation. An output of the correction filter **133** is input to the controller **134**. The output of the correction filter **133** is referred to as a correction signal X (second signal).

The coefficient updater **134***a* of the controller **134** updates a filter coefficient of the silencer filter **135***a*, using a well-known sequential update control algorithm referred to as Filtered-X LMS. The coefficient updater **134***a* calculates the filter coefficient of the silencer filter **135***a*, based on the correction signal X from the correction filter **133** and the error signal e from the A/D converter **125**. The silencer filter **135***a* of this embodiment uses a single filter coefficient common to a whole frequency band of the canceling sound.

Generally in a processing of updating a filter coefficient, using Filtered-X LMS, the filter coefficient is updated such that the error signal e is minimized. In this case, a cost function J is defined by MATHEMATICAL 1 below. In MATHEMATICAL 1, "E" denotes an expected value (long time average), and "n" denotes a sampling number that corresponds to an order for an update timing.

$$J=E[e^2(n)] \quad \text{[MATHEMATICAL 1]}$$

This cost function J is expressed by MATHEMATICAL 2 below based on a steepest descent algorithm.

$$\begin{aligned} W(n+1) &= W(n) - \mu\frac{\partial J}{\partial W}(n) \\ &= W(n) - 2E[x(n)e(n)] \end{aligned} \quad \text{[MATHEMATICAL 2]}$$

Since an error curved surface **31** of the steepest descent algorithm is represented by a quadric surface as shown in FIG. **3**, the least square error is reached by updating a filter coefficient such that its slope is in a negative direction, and the filter coefficient therefore converges. In FIG. **3**, arrows **32** schematically represent that an error converges toward a minimum value at each of update timings. Each arrow **32** shows a change in the error for each of the update timings. In MATHEMATICAL 2, "W", "μ" and "X" denote a filter coefficient, an update parameter and a reference signal, respectively. More specifically, the processing of updating the filter coefficient of the silencer filter **135***a* is expressed by MATHEMATICAL 3 below.

$$W(n+1)=W(n)-2\mu X(n)e(n) \quad \text{[MATHEMATICAL 3]}$$

When a difference between a filter coefficient W(n) and a filter coefficient W(n+1) is reduced to a prescribed reference value or less while the calculation of MATHEMATICAL 3 is repeated for each update timing, the coefficient updater **134***a* determines that the filter coefficient has converged. Generally when a second term of the right side, including the correction signal X, the error signal e and the update parameter μ, is increased, the filter coefficient converges at a faster speed. In other words, a convergence speed of the filter coefficient W depends on sizes of the correction signal X, the error signal e and the update parameter μ.

For example if amplitude of at least one of the correction signal X and the error signal e is large, the filter coefficient W converges fast. On the other hand, if amplitude of the correction signal X and amplitude of the error signal e are small, a long time is taken for that the filter coefficient W converges.

The coefficient updater **134***a* of this embodiment adjusts the convergence speed of the filter coefficient W by multiplying a product of the correction signal X and the error signal e by the update parameter μ. When the update parameter μ is made increased, the time taken for the convergence is decreased. When the update parameter μ is too large, however, there is a possibility that the filter coefficient W does not converge. Accordingly, the coefficient updater **134***a* sets the update parameter μ having an appropriate size in a range where the filter coefficient W can converge.

The coefficient updater **134***a* updates the filter coefficient W of the silencer filter **135***a* by every sampling period. The silencer filter **135***a* subjects the noise signal N and the filter coefficient W to convolution calculation, and outputs this calculation result. An output of the silencer filter **135***a* is phase-inverted by the phase inverter **135***b*, and the canceling signal Y is therefore generated. The canceling signal Y output from the canceling signal generator **135** is subjected to a Digital-Analog conversion by the D/A converter **126**, and then amplified by the amplifier **123**. The canceling signal output from the amplifier **123** is input to the speaker **113**, and the canceling sound is therefore emitted by the speaker **113**.

The canceling signal Y is generated such that a waveform thereof have a reverse phase and same amplitude with respect to a waveform of the noise at the silencing point. The canceling sound is emitted from the speaker **113** based on the canceling signal Y, thereby reducing the noise that is propagated in the object space **21***b* from the fan **22** and emitted through the intake port **21***a*.

Next, a processing upon occurrence of the disturbance sound will be described.

The disturbance sound may often occur by a disturbance around the range hood system **2**, and the referring microphone **111** and the error microphone **112** accordingly may collect the disturbance sound. The disturbance sound collected by the referring microphone **111** is mixed in an output of the referring microphone **111**. Similarly, the disturbance sound collected by the error microphone **112** is mixed in an output of the error microphone **112**. That is, there is a possibility that a component of the disturbance sound is mixed in the correction signal X and the error signal e. In addition, if the disturbance sound is mixed in as least one of the correction signal X and the error signal e, the filter coefficient W may diverge in the processing by the coefficient updater **134***a*. Note that, the disturbance sound corresponds to sound made by a cooking stove, a water flow of a sink or the like, installed below the range hood system **2**, and it is different from the noise made by the fan **22** and the canceling sound output from the speaker **113**.

The controller **134** includes the disturbance detector **134***b*. The disturbance detector **134***b* is configured to detect whether the disturbance sound is mixed. More specifically, the disturbance detector **134***b* determines that mixing of the disturbance sound to the correction signal X is present, when amplitude of a temporal waveform of the correction signal X exceeds a prescribed first threshold. In addition, the disturbance detector **134***b* determines that mixing of the disturbance sound to the error signal e is present, when amplitude of a temporal waveform of the error signal e exceeds a prescribed second threshold. In other words, the disturbance detector **134***b* detects the mixing of the disturbance sound, when amplitude of a temporal waveform of any one of the correction signal X and the error signal e exceeds a predetermined threshold (the first threshold or the second threshold). Hereinafter, "amplitude of a temporal waveform" is simply referred to as "amplitude".

The disturbance detector **134***b* may be configured to detect the mixing of the disturbance sound, when the amplitude of the correction signal X exceeds the first threshold and further the amplitude of the error signal e exceeds the second threshold.

The value of the first threshold is previously set based on the amplitude of the correction signal X generated from an output of the referring microphone **111**, when the disturbance sound is absent while the noise by the fan **22** is present. More specifically, the disturbance detector **134***b* calculates a probability distribution (the average, the variance) of an amplitude peak based on the temporal waveform of the correction signal X, and sets the first threshold to a value, which the amplitude cannot probabilistically exceed when the disturbance sound is absent, based on this probability distribution.

The value of the second threshold is previously set based on the amplitude of the error signal e generated from an output of the error microphone **112**, when the disturbance sound is absent while the noise by the fan **22** is present. More specifically, the disturbance detector **134***b* calculates a probability distribution (the average, the variance) of an amplitude peak based on the temporal waveform of the error signal e, and sets the second threshold to a value, which the amplitude cannot probabilistically exceed when the disturbance sound is absent, based on this probability distribution.

As described above, the disturbance detector **134***b* can detect mixing of the disturbance sound, based on amplitude of a temporal waveform of a signal generated from at least one of outputs of the referring microphone **111** and the error microphone **112**. With this configuration, it is possible to relatively simplify calculation for detecting the mixing of the disturbance sound.

The controller **134** further includes the updating stopper **134***c*. The updating stopper **134***c* is configured to, when the disturbance detector **134***b* detects the mixing of the disturbance sound, cause the coefficient updater **134***a* to stop the processing of updating the filter coefficient W. A time period, during which the processing of updating the filter coefficient W is stopped by the updating stopper **134***c*, corresponds to a time period during which the disturbance detector **134***b* detects the mixing of the disturbance sound. However, the time period, during which the processing of updating the filter coefficient W is stopped by the updating stopper **134***c*, may further include a fixed time period from a time point at which a detected state of mixing of the disturbance sound is changed to a non-detected state, in addition to the time period during which the disturbance detector **134***b* detects the mixing of the disturbance sound. When the stop of the updating processing for the filter coefficient W, by the updating stopper **134***c*, is released, the coefficient updater **134***a* restarts the updating processing for the filter coefficient W.

As described above, the signal processing device **127** stops the updating processing for the filter coefficient W of the silencer filter **135***a* in response to detecting the mixing of the disturbance sound. Accordingly, the silencer filter **135***a* maintains the filter coefficient W, which has been set before the occurrence of the disturbance sound, at a time point of detecting the mixing of the disturbance sound, and it is therefore possible to suppress divergence of the filter coefficient W. In other words, the signal processing device **127** can suppress the divergence of the filter coefficient W, and a reduction in the silencing performance caused by adaptation to the disturbance sound, even when the disturbance sound is collected in the active noise control. Furthermore, the program to be executed by the signal processing device **127** and the range hood system **2** with the silencing circuit **12** can also provide the above-mentioned same effect.

The output stopper **134***d* of the controller **134** monitors an output of the silencer filter **135***a* (i.e., a signal that is inverted to make the canceling signal Y), and stops the output of the silencer filter **135***a* when an output value of the silencer filter **135***a* exceeds a prescribed threshold. The output value of the silencer filter **135***a* is treated as a variable in the program to be executed by the signal processing device **127**. This variable has a permissible range (an upper limit and a lower limit) as shown in TABLE 1 below.

TABLE 1

Input Voltage (V) of Amplifier 123	Variable (Code)	
+V1	+aaaaa	Upper Limit
+V2	+bbbbb	
0	00000	
−V2	−bbbbb	
−V1	−aaaaa	Lower Limit

If the output value of the silencer filter **135***a* is out of the permissible range, there is a case where the filter coefficient W diverges due to that the speaker **113** emits the canceling sound at large volume or the system causes malfunction. To solve this, as described above, when a volume of the canceling sound output by the speaker **113** exceeds a prescribed volume, outputting of the canceling sound by the speaker **113** is stopped. As a result, the filter coefficient W is prevented from diverging.

Next, an identification processing for the transfer functions C and F to be performed by the function determiner **134***e* will be described. FIG. **4** shows a relationship between the identification processing for the transfer functions C and F and the processing of updating the filter coefficient W. The function determiner **134***e* performs the identification processing for the transfer functions C and F (Step S**1**), and then determines the transfer functions C and F (Step S**2**). The filter coefficient of the correction filter **133** is then set with the transfer function C determined by the function determiner **134***e*. Also, the filter coefficient of the howling cancel filter **131** is set with the transfer function F determined by the function determiner **134***e*. After that, the coefficient updater **134***a* performs the processing of updating the filter coefficient W described above (Step S**3**). The identification processing for the transfer functions C and F may be performed at the factory shipment, after the site construction, or the like.

FIG. **5** schematically shows the identification processing for the transfer function C by the function determiner **134***e*. Note that, functions of a known sound generator **141** and a subtractor **142** in FIG. **5** may be also realized by a program being executed by the device that constitutes the signal processing device **127**.

The signal processing device **127** includes the known sound generator **141** that outputs, as a known signal, a signal including white noise (a white noise signal). The function determiner **134***e* (refer to FIG. **1**) inputs the white noise signal of the known sound generator **141** to the D/A converter **126**, and gives an output of the D/A converter **126** to the speaker **113** via the amplifier **123** to output the white noise from the speaker **113**. The white noise output from the speaker **113** is collected by the error microphone **112**, and accordingly, the error microphone **112** outputs a known sound signal (fourth signal). The known sound signal is input to the subtractor **142** via the amplifier **122** and the A/D converter **125**.

The white noise signal of the known sound generator **141** is also input to the silencer filter **135***a* and the coefficient updater **134***a*. The subtractor **142** outputs a signal, obtained by subtracting the known sound signal from an output of the silencer filter **135***a*, to the coefficient updater **134***a*. The coefficient updater **134***a* updates the filter coefficient of the silencer filter **135***a* such that an output of the subtractor **142** is minimized. The filter coefficient in the silencer filter **135***a*, at when the filter coefficient has converged by this update processing, is the transfer function C determined by the function determiner **134***e*.

That is, the coefficient updater **134***a* updates the filter coefficient of the silencer filter **135***a* such that a difference is minimized, the difference being between: the known sound signal generated based on an output of the error microphone **112**; and a signal obtained by making the white noise signal as the known signal pass through the silencer filter **135***a*. The coefficient updater **134***a* repeatedly updates the filter coefficient, and accordingly, the filter coefficient of the silencer filter **135***a* can be made to be closer to a truth transfer function.

When the disturbance detector **134***b* detects mixing of the disturbance sound to the output of the error microphone **112** while the function determiner **134***e* performing the identification processing for the transfer function C, the updating stopper **134***c* causes the coefficient updater **134***a* to stop the processing of updating the filter coefficient of the silencer filter **135***a*. By this stop processing, it is possible to suppress the filter coefficient from diverging during the identification processing for the transfer function C by the function determiner **134***e*. When the stop of the update processing for the filter coefficient, by the updating stopper **134***c*, is then released, the coefficient updater **134***a* restarts the updating processing for the filter coefficient. As described above, the function determiner **134***e* can calculate the transfer function C with higher accuracy, even when the disturbance sound is present, and accordingly, it is possible to obtain high silencing performance.

Similarly to the determination processing for the transfer function C described above, the function determiner **134***e* also performs a determination processing for the transfer function F, using an output of the referring microphone **111** that has collected the white noise. When the disturbance detector **134***b* detects mixing of the disturbance sound to the output of the referring microphone **111** while the function determiner **134***e* performing the identification processing for the transfer function F, the coefficient updater **134***a* stops the processing of updating the filter coefficient of the silencer filter **135***a*. Therefore, it is possible to suppress the filter coefficient from diverging during the identification processing for the transfer function F by the function determiner **134***e*. When the stop of the update processing for the filter coefficient, by the updating stopper **134***c*, is then released, the coefficient updater **134***a* restarts the updating processing for the filter coefficient. As described above, the function determiner **134***e* can calculate the transfer function F with higher accuracy, even when the disturbance sound is present, and accordingly, it is possible to obtain high silencing performance.

FIG. **6** shows a temporal waveform of the error signal output by the error microphone **112** in case the disturbance detector **134***b* is not made operated. In the case of FIG. **6**, the disturbance sound (impulsive sound) occurs at a time t**1**. In the exemplary operation of FIG. **6**, the update processing for the filter coefficient W is continued without operating the disturbance detector **134***b*. For this reason, the filter coefficient W diverges due to the disturbance sound after the time t**1** and the amplitude of the error signal is increased by the silencing effect being deteriorated.

On the other hand, FIG. **7** shows a temporal waveform of the error signal output by the error microphone **112** in case the disturbance detector **134***b* is made operated. In the case of FIG. **7**, the disturbance sound (impulsive sound) occurs at a time t**2**. In the exemplary operation of FIG. **7**, the disturbance detector **134***b* detects the disturbance sound, and the filter coefficient W is therefore stopped to be updated. When the disturbance sound becomes absent, the update of the filter coefficient W is restarted. For this reason, the amplitude of the error signal is reduced by the noise being suppressed by the canceling sound after the time t**2**.

(Embodiment 2)

A controller **134** of a silencer **1** has a configuration as shown in FIG. **8**. A silencer filter **135***a* of this embodiment has two or more filter coefficients W**1** to Wk that respectively correspond to two or more frequency bins, into which a whole frequency band of a canceling sound is divided, the number of the frequency bins being “k”. In addition, a coefficient updater **134***a* includes two frequency converters **151** and **152**, a coefficient adjuster **153** and an inverse converter **154**. Note that, because other elements are similar to those of Embodiment 1, such similar elements are denoted by same signs and explanations thereof are omitted.

The frequency converter **151** converts a correction signal X to a signal of a frequency domain by FFT (Fast Fourier Transform). The frequency converter **152** converts an error signal e to a signal of a frequency domain by FFT (Fast Fourier Transform).

The coefficient adjuster **153** receives the correction signal X of the frequency domain and the error signal e of the frequency domain. The coefficient adjuster **153** executes an algorithm of Filtered-X LMS in the frequency domain to set update parameters μ**1** to μk that respectively correspond to the frequency bins, and calculates and outputs the filter coefficients W**1** to Wk corresponding to the frequency bins of the silencer filter **135***a*. Furthermore, the coefficient adjuster **153** can adjust a convergence speed for each frequency bin, by setting the update parameters μ**1** to μk corresponding to the frequency bins.

The inverse converter **154** executes IFFT (Inverse Fast Fourier Transform) to convert an output of the coefficient adjuster **153** to a signal of a time domain. The filter coefficients W**1** to Wk corresponding to the frequency bins of the silencer filter **135***a* are set by an output of the inverse converter **154**.

The coefficient updater **134***a* updates the filter coefficients W**1** to Wk of the silencer filter **135***a* by every sampling period. The silencer filter **135***a* divides a noise signal N in units of the frequency bins, and subjects, in the units of the frequency bins, the noise signal N and the filter coefficients W**1** to Wk to convolution calculation. The silencer filter **135***a* outputs the sum of results of the convolution calculation performed in the units of the frequency bins. Then an output of the silencer filter **135***a* is phase-inverted by a phase inverter **135***b*, thereby a canceling signal Y being generated. The canceling signal Y output from a canceling signal generator **135** is subjected to a Digital-Analog conversion by a D/A converter **126**, and then amplified by an amplifier **123**. An output of the amplifier **123** is input to a speaker **113**, and the canceling sound is therefore emitted by the speaker **113**.

The canceling sound (canceling signal Y) is generated such that a waveform thereof have a reverse phase and same amplitude with respect to a waveform of the noise at a silencing point, and reduces the noise that is propagated in a hood **21** from a fan **22** and emitted through an intake port **21***a*.

Next, a processing upon occurrence of disturbance sound will be described.

A disturbance detector **134***b* of this embodiment determines whether or not mixing of the disturbance sound is present, using the correction signal X of the frequency domain and the error signal e of the frequency domain. More specifically, a frequency distribution for the noise is previously analyzed, and the disturbance detector **134***b* previously stores data of frequency distributions for the correction signal X and the error signal e (noise distribution data) under a condition that the noise is present. Note that the noise distribution data may be data of frequency distributions for the correction signal X and the error signal e under a condition that both the noise signal and the canceling signal occur. That is, the noise distribution data can be said to be data representing the frequency distribution for the noise.

The disturbance detector **134***b* compares the frequency distribution for the correction signal X with the noise distribution data, and determines that mixing of the disturbance sound to the correction signal X is present, when the frequency distribution for the correction signal X is different from the noise distribution data. Also, the disturbance detector **134***b* compares the frequency distribution for the error signal e with the noise distribution data, and determines that mixing of the disturbance sound to the error signal e is present, when the frequency distribution for the error signal e is different from the noise distribution data. In short, the disturbance detector **134***b* detects mixing of the disturbance sound, when any one of the frequency distributions for the correction signal X and the error signal e is different from the noise distribution data.

For example, there is a possibility of adverse influence on a processing of updating a filter coefficient in case amplitude (a spectrum value) of a specific frequency component is increased due to the disturbance sound even if amplitude (an overall value) of the correction signal X or the error signal e is small. For this reason, it is to compare a frequency distribution for a signal generated based on at least one of outputs of a referring microphone **111** and an error microphone **112** with the frequency distribution for the noise. Accordingly, it is possible to improve detection accuracy for the disturbance sound by mixing of the disturbance sound being detected based on the frequency distribution.

Alternatively, the disturbance detector **134***b* may detect mixing of the disturbance sound, when both of the frequency distributions for the correction signal X and the error signal e are different from the noise distribution data.

An updating stopper **134***c* previously stores data of a frequency band of the noise that is made by the fan **22**, which is an object to be silenced. Here the frequency band of the noise, which is the object to be silenced, may be different from a frequency band of the disturbance sound. For this reason, the updating stopper **134***c* is configured to, when the disturbance detector **134***b* detects the mixing of the disturbance sound, cause the coefficient updater **134***a* to stop a processing of updating the filter coefficient W, relating to only a frequency band(s) other than the frequency band of the noise. More specifically, when the mixing of the disturbance sound is detected, the updating stopper **134***c* causes the coefficient updater to stop the processing of updating the filter coefficient W, relating to, as an object, only a frequency bin(s), which does not correspond to the frequency band of the noise.

It is therefore possible to reduce a frequency of stopping the update of the filter coefficient W about the frequency band of the noise, and accordingly, it is possible to, regarding the frequency band of the noise, increase a convergence speed of the filter coefficient W, which is also related to the silencing performance. In addition, since the update of the filter coefficient W about the frequency band(s) other than the frequency band of the noise is stopped when the disturbance sound is detected, it is possible to suppress divergence of the filter coefficient W.

(Embodiment 3)

The disturbance detector **134***b* of Embodiment 1 or 2 specifies a direction where the sound source is positioned, based on an output of the referring microphone **111** and an output of the error microphone **112**, and detects mixing of the disturbance sound based on the direction of the sound source. In other words, the disturbance detector **134***b* estimates the direction of the sound source that has made sound collected by the referring microphone **111** and the error microphone **112**, and determines that the mixing of the disturbance sound is present, when the estimated direction of the sound source is different from an installation direction of the fan **22**.

For example, the disturbance detector **134***b* obtains the direction of the sound source, as described below. To obtain the direction of the sound source, it is necessary to derive a time difference (arrival time difference) between times required for that sound waves emitted from the sound source enter the referring microphone **111** and the error microphone **112**, respectively. This time difference may be calculated by a function of a correlation between the output of the referring microphone **111** and the output of the error microphone **112**. When the obtained arrival time difference is multiplied by the speed of sound (about 340 m/s at normal temperature), a distance L**1** as shown in FIG. **9** is obtained.

Also as shown in FIG. **9**, a relationship of "the distance $L1=d\cdot\sin\theta$" is met, where "d" denotes a distance between the referring microphone **111** and the error microphone **112**, and "θ" denotes an angle that is formed by: a straight line connecting the referring microphone **111** and the error microphone **112**; and the direction where the sound source is positioned. In this embodiment, the angle θ is defined as the direction of the sound source. Accordingly, the disturbance detector **134***b* can obtain the direction θ of the sound source by "the arrival time difference×the speed of sound=$d\cdot\sin\theta$", thereby specifying the direction where the sound source is positioned.

Here a direction where the fan **22** as the noise source is positioned is known, and the fan **22** is positioned in a direction toward not the side of the error microphone **112** but the side of the referring microphone **111**. The disturbance detector **134***b* stores data of a prescribed angle range, as the direction where the fan **22** is positioned, and determines that the sound source is the fan **22**, when the direction θ of the sound source is within the angle range. On the other hand, the disturbance detector **134***b* determines that the sound source is a disturbance other than the fan when the direction θ of the sound source is out of the angle range, and detects mixing of the disturbance sound.

Here the direction of the sound source of this embodiment is added to a determination condition for detection of the disturbance sound to be performed by the disturbance detector **134***b* of Embodiment 1 or 2, and it is therefore possible to improve detection accuracy for the disturbance sound.

Note that, in each of the embodiments described above, the fan **22** of the range hood system **2** is cited as the noise source, however, the noise source is not limited to the fan **22**. For example, the silencer **1** may be installed in a noise propagation path, such as a casing of an electrical apparatus, an air-conditioning duct or a tunnel, to suppress the noise propagating in the noise propagation path.

In each of the embodiments described above, a silencing circuit **12** is to be used in combination with a sound input/output device **11** that includes a referring microphone **111** (first sound inputter), an error microphone **112** (second sound inputter) and a speaker **113** (sound outputter). The referring microphone **111** is installed in a space, where noise made by a fan **22** (noise source) is propagated, to collect the noise. The speaker **113** is configured to output a canceling sound for canceling the noise to the space in response to receiving a canceling signal. The error microphone **112** is configured to collect a synthesized sound of the noise and the canceling sound in the space. The silencing circuit **12** includes a canceling signal generator **135**, a correction filter **133**, a coefficient updater **134***a*, a disturbance detector **134***b* and an updating stopper **134***c*.

The canceling signal generator **135** includes a silencer filter **135***a* with a filter coefficient, and is configured to output the canceling signal Y in response to receiving a noise signal N (first signal) generated based on an output of the referring microphone **111**. The correction filter **133** is configured to generate a correction signal X (second signal) by correcting the noise signal N based on a transfer function C of an acoustic path from the speaker **113** to the error microphone **112**.

The coefficient updater **134***a* is configured to calculate the filter coefficient based on the correction signal X and an error signal e (third signal) generated from an output of the error microphone **112**, and update the filter coefficient of the silencer filter **135***a*. The disturbance detector **134***b* is configured to detect mixing of disturbance sound, different from each of the noise and the canceling sound, to at least one of the output of the referring microphone **111** and the output of the error microphone **112**. The updating stopper **134***c* is configured to, when the disturbance detector **134***b* detects the mixing of the disturbance sound, cause the coefficient updater **134***a* to stop a processing of updating the filter coefficient, relating to at least a frequency band other than a frequency band of the noise.

A program that is executed by a signal processing device **127** is to be stored in a computer that is used in combination with a sound input/output device **11**. The sound input/output device **11** includes a referring microphone **111** (first sound inputter), an error microphone **112** (second sound inputter) and a speaker **113** (sound outputter). The referring microphone **111** is installed in a space, where noise made by a fan **22** (noise source) is propagated, to collect the noise. The speaker **113** is configured to output a canceling sound for canceling the noise to the space in response to receiving a canceling signal. The error microphone **112** is configured to collect a synthesized sound of the noise and the canceling sound in the space. The program causes the computer to realize functions as follows:

[FUNCTION 1] to constitute a silencer filter **135***a* with a filter coefficient, and output the canceling signal Y in response to receiving a noise signal N (first signal) generated based on an output of the referring microphone **111**;

[FUNCTION 2] to generate a correction signal X (second signal) by correcting the noise signal N based on a transfer function C of an acoustic path from the speaker **113** to the error microphone **112**;

[FUNCTION 3] to calculate the filter coefficient based on the correction signal X and an error signal e (third signal) generated from an output of the error microphone **112**, and update the filter coefficient of the silencer filter **135***a;*

[FUNCTION 4] to detect mixing of disturbance sound, different from each of the noise and the canceling sound, to at least one of the output of the referring microphone **111** and the output of the error microphone **112**; and

[FUNCTION 5] to, when the mixing of the disturbance sound is detected, stop a processing of updating the filter coefficient, relating to at least a frequency band other than a frequency band of the noise.

This aspect of the present invention is not limited to the program, but may be a computer-readable recording medium that records the program.

A range hood system **2** includes a hood **21**, a fan **22**, a referring microphone **111** (first sound inputter), an error microphone **112** (second sound inputter), a speaker **113** (sound outputter) and a silencing circuit **12**.

The hood **21** corresponds to a ventilation passage that has a hollow tubular shape. The fan **22** corresponds to an air blower that is configured to generate air flow from a first end of the hood **21** to a second end of the hood **21**. The referring microphone **111** is installed in the hood **21** to collect noise made by the fan **22**. The speaker **113** is configured to output a canceling sound for canceling the noise to the hood **21** in response to receiving a canceling signal. The error microphone **112** is configured to collect a synthesized sound of the noise and the canceling sound in the hood **21**. The silencing circuit **12** is configured to generate the canceling signal.

The silencing circuit **12** includes a canceling signal generator **135**, a correction filter **133**, a coefficient updater **134***a*, a disturbance detector **134***b* and an updating stopper **134***c*.

The canceling signal generator **135** includes a silencer filter **135***a* with a filter coefficient, and is configured to output the canceling signal Y in response to receiving a noise signal N (first signal) generated based on an output of the referring microphone **111**. The correction filter **133** is configured to generate a correction signal X (second signal) by correcting the noise signal N based on a transfer function C of an acoustic path from the speaker **113** to the error microphone **112**.

The coefficient updater **134***a* that is configured to calculate the filter coefficient based on the correction signal X and an error signal e (third signal) generated from an output of the error microphone **112**, and update the filter coefficient of the silencer filter **135***a*. The disturbance detector **134***b* is configured to detect mixing of disturbance sound, different from each of the noise and the canceling sound, to at least one of the output of the referring microphone **111** and the output of the error microphone **112**. The updating stopper **134***c* is configured to, when the disturbance detector **134***b* detects the mixing of the disturbance sound, cause the coefficient updater **134***a* to stop a processing of updating the filter coefficient, relating to at least a frequency band other than a frequency band of the noise.

Note that, the embodiments described above are examples of the present invention. For this reason, the present invention is not limited to the embodiments described above, and various modifications can be made according to the design or the like even in a case other than the embodiments, as long as they do not depart from the technical ideas of the present invention.

The invention claimed is:

1. A signal processing device to be used in combination with a sound input/output device, the sound input/output device comprising:

- a first sound inputter that is installed in a space, where noise made by a noise source is propagated, to collect the noise;
- a sound outputter that is configured to output a canceling sound for canceling the noise to the space in response to receiving a canceling signal; and
- a second sound inputter that is configured to collect a synthesized sound of the noise and the canceling sound in the space,

the signal processing device comprising:

- a canceling signal generator that comprises a silencer filter with a filter coefficient, and is configured to output the canceling signal in response to receiving a first signal generated based on an output of the first sound inputter;
- a correction filter that is configured to generate a second signal by correcting the first signal based on a transfer function of an acoustic path from the sound outputter to the second sound inputter;
- a coefficient updater that is configured to calculate the filter coefficient based on the second signal and a third signal generated from an output of the second sound inputter, and update the filter coefficient of the silencer filter;
- a disturbance detector that is configured to detect mixing of disturbance sound, different from each of the noise and the canceling sound, to at least one of the output of the first sound inputter and the output of the second sound inputter; and
- an updating stopper that is configured to, when the disturbance detector detects the mixing of the disturbance sound, cause the coefficient updater to stop a processing of updating the filter coefficient, relating to at least a frequency band other than a frequency band of the noise.

2. The signal processing device according to claim 1, wherein

the updating stopper is configured to, when the disturbance detector detects the mixing of the disturbance sound, causes the coefficient updater to stop the processing of updating the filter coefficient, relating to, as an object, a whole frequency band of the canceling sound.

3. The signal processing device according to claim 1, wherein

the updating stopper is configured to, when the disturbance detector detects the mixing of the disturbance sound, cause the coefficient updater to stop the processing of updating the filter coefficient, relating to only the frequency band other than the frequency band of the noise.

4. The signal processing device according to claim 3, wherein:

the silencer filter is configured to divide a prescribed frequency band into two or more frequency bins, and have the filter coefficient for each frequency bin; and the updating stopper is configured to, when the disturbance detector detects the mixing of the disturbance sound, cause the coefficient updater to stop the processing of updating the filter coefficient, relating to, as an object, only a frequency bin, which corresponds to the frequency band other than the frequency band of the noise, of the two or more frequency bins.

5. The signal processing device according to claim 1, wherein

the disturbance detector that is configured to detect the mixing of the disturbance sound, when amplitude of a temporal waveform of a signal, generated based on at least one of the output of the first sound inputter and the output of the second sound inputter, exceeds a threshold based on amplitude of a temporal waveform of the noise.

6. The signal processing device according to claim 1, wherein

the disturbance detector that is configured to:

compare a frequency distribution of a signal, generated based on at least one of the output of the first sound inputter and the output of the second sound inputter, with a frequency distribution of the noise; and

detect the mixing of the disturbance sound based on a compared result.

7. The signal processing device according to claim 1, wherein

the disturbance detector that is configured to:

derive a time difference based on a correlation between the output of the first sound inputter and the output of the second sound inputter, the time difference being a difference between a time required for that a sound made by a sound source reaches the first sound inputter and is collected by the first sound inputter and a time required for that the sound made by the sound source reaches the second sound inputter and is collected by the second sound inputter;

estimate a direction, where the sound source is positioned, based on the time difference; and

detect the mixing of the disturbance sound, when the direction where the sound source is positioned is different from a direction where the noise source is positioned.

8. The signal processing device according to claim 1, causing the sound outputter to stop outputting of the canceling sound, when a volume of the canceling sound output by the sound outputter exceeds a prescribed volume.

9. The signal processing device according to claim 1, further comprising:

a known sound generator that is configured to input a known signal to the sound outputter so as to cause the sound outputter to output a known sound; and

a function determiner that is configured to determine the transfer function, wherein:

the second sound inputter is configured to output a fourth signal in response to collecting the known sound;

the coefficient updater is configured to update the filter coefficient of the silencer filter such that a difference between the known signal passing through the silencer filter and the fourth signal is minimized;

the function determiner is configured to determine the transfer function based on the filter coefficient; and

the updating stopper is configured to, when the disturbance detector detects the mixing of the disturbance sound, cause the coefficient updater to stop the processing of updating the filter coefficient.

10. A computer-readable, non-transitory, and tangible recording medium recording a program to be stored in a computer that is used in combination with a sound input/output device, the sound input/output device comprising:

a first sound inputter that is installed in a space, where noise made by a noise source is propagated, to collect the noise;

a sound outputter that is configured to output a canceling sound for canceling the noise to the space in response to receiving a canceling signal; and

a second sound inputter that is configured to collect a synthesized sound of the noise and the canceling sound in the space,

the program causing the computer to realize:

a function to constitute a silencer filter with a filter coefficient, and output the canceling signal in response to receiving a first signal generated based on an output of the first sound inputter;

a function to generate a second signal by correcting the first signal based on a transfer function of an acoustic path from the sound outputter to the second sound inputter;

a function to calculate the filter coefficient based on the second signal and a third signal generated from an output of the second sound inputter, and update the filter coefficient of the silencer filter;

a function to detect mixing of disturbance sound, different from each of the noise and the canceling sound, to at least one of the output of the first sound inputter and the output of the second sound inputter; and

a function to, when the mixing of the disturbance sound is detected, stop a processing of updating the filter coefficient, relating to at least a frequency band other than a frequency band of the noise.

11. A range hood system, comprising:

a ventilation passage that has a hollow tubular shape;

an air blower that is configured to generate air flow from a first end of the ventilation passage to a second end of the ventilation passage;

a first sound inputter that is installed in the ventilation passage to collect noise made by the air blower;

a sound outputter that is configured to output a canceling sound for canceling the noise to the ventilation passage in response to receiving a canceling signal;

a second sound inputter that is configured to collect a synthesized sound of the noise and the canceling sound in the ventilation passage; and

a signal processing device that is configured to generate the canceling signal, the signal processing device comprising:

a canceling signal generator that comprises a silencer filter with a filter coefficient, and is configured to output the canceling signal in response to receiving a first signal generated based on an output of the first sound inputter;

a correction filter that is configured to generate a second signal by correcting the first signal based on a transfer function of an acoustic path from the sound outputter to the second sound inputter;

a coefficient updater that is configured to calculate the filter coefficient based on the second signal and a third signal generated from an output of the second sound inputter, and update the filter coefficient of the silencer filter;

a disturbance detector that is configured to detect mixing of disturbance sound, different from each of the noise and the canceling sound, to at least one of the output of the first sound inputter and the output of the second sound inputter; and

an updating stopper that is configured to, when the disturbance detector detects the mixing of the disturbance sound, cause the coefficient updater to stop a processing of updating the filter coefficient, relating to at least a frequency band other than a frequency band of the noise.

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