FIG. 3

(57) Abstract: An echo cancellation apparatus is connectable to a speaker configured to output speaker signals and a microphone configured to receive a sound from the speaker and including a plurality of microphone elements. The echo cancellation apparatus includes: a generating unit configured to generate a plurality of sensitivity signals having different sensitivity patterns which represent directionality of the microphone, based on a plurality of microphone signals obtained from the respective microphone signals; a delay estimating unit configured to determine a shortest delay time as an estimated delay time, the shortest delay time being a shortest one of delay times between the speaker signals and the microphone signals, the delay times being obtained from the respective sensitivity signals; and an echo suppressing unit configured to suppress echoes of the plurality of microphone signals using the estimated delay time.
AMENDED CLAIMS
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1. (Amended) An echo cancellation apparatus connectable to a speaker configured to output speaker signals and a microphone configured to receive a sound from the speaker and comprising a plurality of microphone elements, said echo cancellation apparatus comprising:
   a generating unit configured to generate a plurality of sensitivity signals corresponding to different sensitivity patterns which represent directionality of the microphone, based on a plurality of microphone signals obtained from the respective microphone elements, each of the sensitivity signals representing how much a microphone signal is correlated with a signal obtained by shifting a speaker signal by a delay time;
   a delay estimating unit configured to determine a shortest delay time as an estimated delay time, the shortest delay time being a shortest one of delay times corresponding to peaks of the sensitivity signals; and
   an echo suppressing unit configured to suppress echoes of the plurality of microphone signals using the estimated delay time.

2. The echo cancellation apparatus according to claim 1, wherein in a case where a number of the plurality of microphone elements is two, a sensitivity signal $c$ obtained from the microphone signals is expressed as an equation as follows:
   $$c = k_1c_1 + k_2c_2$$
   where $c_1$ and $c_2$ denote the sensitivity signals obtained from the respective microphone signals, and $k_1$ and $k_2$ denote arbitrary real numbers.

3. The echo cancellation apparatus according to claim 1 or 2, wherein in a case where the shortest delay time is larger than a first predetermined time, a time obtained by subtracting the first predetermined time from the shortest delay time is determined as the estimated delay time of the speaker signals, and wherein in a case where the shortest delay time is smaller than the first predetermined time, the shortest delay time is determined as the estimated delay time of the speaker signals.
4. The echo cancellation apparatus according to any one of claims 1 to 3, wherein in a case where there is a change in the delay time, if a changed time is smaller than a second predetermined time, an estimated delay time before the change is determined as the estimated delay time of the speaker signals.

5. The echo cancellation apparatus according to any one of claims 1 to 4, further comprising:
   a frequency-band limiting unit configured to limit frequency bands of the microphone signals and the speaker signals,
   wherein the microphone signals and the speaker signals band-limited and down-sampled by the frequency-band limiting unit are transmitted to the delay estimating unit.

6. The echo cancellation apparatus according to any one of claims 1 to 4, further comprising:
   a frequency-band splitting unit configured to split the microphone signals and the speaker signals into a plurality of frequency bands, and configured to down-sample the microphone signals and the speaker signals of the frequency bands,
   wherein the delay estimating unit estimates a delay time between the microphone signals and the speaker signals for each of the frequency bands, and determines the shortest delay time of the delay times estimated for the respective frequency bands, as the estimated delay time.

7. The echo cancellation apparatus according to any one of claims 1 to 4, further comprising:
   a frequency-band splitting unit configured to split the microphone signals and the speaker signals into a plurality of frequency bands, and configured to down-sample the microphone signals and the speaker signals of the frequency bands;
   a power calculating unit configured to calculate power of the speaker signals for each of the frequency bands; and
   a determining unit configured to determine at least one of the frequency bands to
be used, based on the power for each of the frequency bands,
    wherein the microphone signals and the speaker signals of the frequency band
determined by the determining unit are transmitted to the delay estimating unit.

8. (Amended) An echo cancellation method for an echo cancellation apparatus
    connectable to a speaker configured to output speaker signals and a microphone configured
to receive a sound from the speaker and comprising a plurality of microphone elements,
said echo cancellation method comprising:
    generating a plurality of sensitivity signals corresponding to different sensitivity
    patterns which represent the directionality of the microphone, based on a plurality of
    microphone signals obtained from the respective microphone elements, each of the
    sensitivity signals representing how much a microphone signal is correlated with a signal
    obtained by shifting a speaker signal by a delay time;
    determining a shortest delay time as an estimated delay time, the shortest delay
time being a shortest one of delay times corresponding to peaks of the sensitivity signals;
    and
    suppressing echoes of the plurality of microphone signals using the estimated
delay time.

9. The echo cancellation method according to claim 8,
    wherein in a case where a number of the plurality of microphone elements is two,
a sensitivity signal c obtained from the microphone signals is expressed as an equation as
follows:
    \[ c = k_1c_1 + k_2c_2 \]
    where c1 and c2 denote the sensitivity signals obtained from the respective
    microphone signals, and k1 and k2 denote arbitrary real numbers.

10. The echo cancellation method according to claim 8 or 9,
    wherein in a case where the shortest delay time is larger than a first predetermined
time, a time obtained by subtracting the first predetermined time from the shortest delay
time is determined as the estimated delay time of the speaker signals, and
    wherein in a case where the shortest delay time is smaller than the first
predetermined time, the shortest delay time is determined as the estimated delay time of the speaker signals.

11. The echo cancellation method according to any one of claims 8 to 10, wherein in a case where there is a change in the delay time, if a changed time is smaller than a second predetermined time, an estimated delay time before the change is determined as the estimated delay time of the speaker signals.

12. (Amended) A teleconferencing system comprising:
- a speaker configured to output speaker signals;
- a microphone configured to receive a sound from the speaker and comprising a plurality of microphone elements; and
- an echo cancellation apparatus connected to the speaker and the microphone, wherein the echo cancellation apparatus comprising:
  - a generating unit configured to generate a plurality of sensitivity signals corresponding to different sensitivity patterns which represent directionality of the microphone, based on a plurality of microphone signals obtained from the respective microphone elements, each of the sensitivity signals representing how much a microphone signal is correlated with a signal obtained by shifting a speaker signal by a delay time;
  - a delay estimating unit configured to determine a shortest delay time as an estimated delay time, the shortest delay time being a shortest one of delay times corresponding to peaks of the sensitivity signals; and
  - an echo suppressing unit configured to suppress echoes of the plurality of microphone signals using the delay time.

13. The teleconferencing system according to claim 12, wherein in a case where a number of the plurality of microphone elements is two, a sensitivity signal \( c \) obtained from the microphone signals is expressed as an equation as follows:
\[
  c = k_1c_1 + k_2c_2
\]
where \( c_1 \) and \( c_2 \) denote the sensitivity signals obtained from the respective microphone signals, and \( k_1 \) and \( k_2 \) denote arbitrary real numbers.
14. The teleconferencing system according to claim 12 or 13,
wherein in a case where the shortest delay time is larger than a first predetermined time, a time obtained by subtracting the first predetermined time from the shortest delay time is determined as the estimated delay time of the speaker signals, and
wherein in a case where the shortest delay time is smaller than the first predetermined time, the shortest delay time is determined as the estimated delay time of the speaker signals.

15. The teleconferencing system according to any one of claims 12 to 14,
wherein in a case where there is a change in the delay time, if a changed time is smaller than a second predetermined time, an estimated delay time before the change is determined as the estimated delay time of the speaker signals.