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Multi-channel automatic gain control

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ABSTRACT

Automatic gain control (AGC) in audio conferencing aims to produce an even speech output level, e.g., by amplifying weak speech and attenuating strong speech. A non-zero adaptation time is needed to reliably measure current speech level prior to applying gain, e.g., too fast an application of gain can result in over- and under-shooting, which manifests as unpleasant aural artifacts. When multiple voices of varying strength in a room take turns speaking, the AGC re-adapts frequently, resulting in audible and unnatural aural side-effects.

Techniques of this disclosure provide automatic gain control for each microphone, and apply the AGC gain after microphone selection but before mixing of microphone signals. Gains are adapted only across selected microphones, or microphones with energy levels similar to a selected microphone. In this manner, the techniques produce an even speech output level without the potentially jarring side-effects of AGC adaptation.

KEYWORDS

Audio conferencing; automatic gain control; microphone selection; AGC adaptation; multi-channel AGC; audio artifact; conference room

BACKGROUND

Modern audio-conferencing systems can host several microphones, e.g., in the low-to-high tens of microphones. The microphones can be spread throughout a conference room. Such a relatively high number of microphones helps achieve excellent clarity, pick-up of a large dynamic range of speech, and telepresence at the far end. Automatic gain control (AGC) is an adaptive mechanism to create a near-constant level of speech output from a microphone or microphone array.
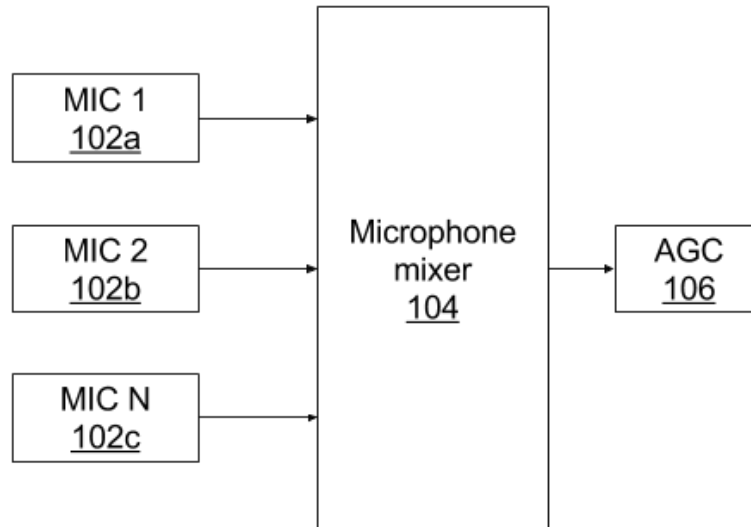
Fig. 1: A single AGC at the output of the mixed (combined) output of an array of microphones

When a number of microphones (102a-c) are assembled into an array, as shown in Fig. 1, a single AGC (106) loop at the output of the microphone mixer or array combiner (104) can result in some undesirable effects. For example, if two voices, one loud and one soft, alternate, AGC adaptation results in frequent fluctuations to gain. At the far end, this is perceived with some aural discomfort: when the loud voice gives way to the soft, the gain is too low, further attenuating or clipping the incipient soft voice. When the soft voice gives way to the loud voice, the far end at first hears an amplified version of an already loud voice before AGC brings down the volume.
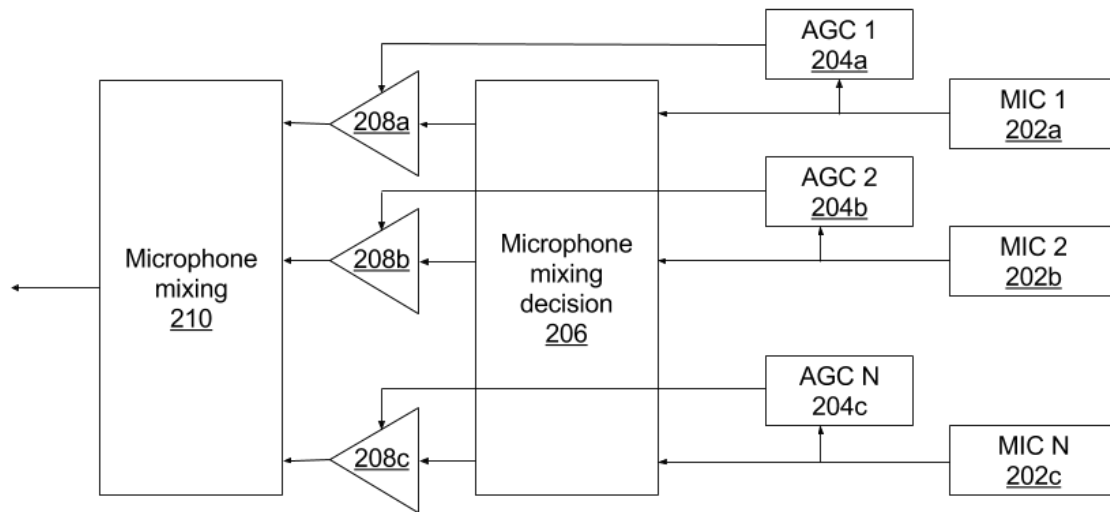
DESCRIPTION

Fig. 2: Multi-channel automatic gain control

Fig. 2 illustrates an example of a multi-channel automatic gain control, per techniques of this disclosure. A microphone array comprises N microphones (202a-c) or devices. Each microphone or device is equipped with an automatic gain control unit (204a-c). The output level of a microphone is measured by the corresponding automatic gain control unit. The AGC units each compute gains to be applied to the outputs of the microphones such that energy levels across microphones are almost equal after the application of the gains. However, such gain is not applied to a microphone output until after the microphone is selected by the microphone mixing decision unit (206).

The function of the microphone mixing decision unit is to select the microphone signals to be combined. The mixing decision is based on the energy level of a microphone signal prior to gain application, whether or not speech is detected at sufficiently strong levels, etc. The gain computed by an AGC unit is applied at amplifiers 208a-c, only to microphones selected by the

microphone mixing decision unit. A microphone mixing unit (210) combines gain-adjusted microphone signals that have been selected.

By providing an AGC loop for each microphone, the microphone signal level is adjusted to the speech signal closest to it. Thus, a microphone that picks up a low voice will apply a high gain, and a microphone close to a loud voice will apply a low gain, such that when these signals are mixed, e.g., combined by addition, both voices are heard about evenly at the far end. Per techniques herein, since the AGC of a given microphone locks to a human speaker, even if only for the duration that the human speaker is close to the microphone, there is no need for sudden re-adaptation to higher / lower voices, and consequent appearance of audio artifacts is prevented.

The function of the microphone mixing decision unit is to pick out the one or more microphones that have speech of sufficient strength. If a microphone is not selected by the microphone mixing decision unit, then it is likely that that corresponding signal has significant ambient (e.g., papers shuffling, fingers tapping the table, ventilation, etc.) or thermal noise. An AGC loop that adapts on noise, especially noise that originates close to a microphone, is likely to produce an abnormally low, non-stationary, and/or incorrect value for gain. Per techniques of this disclosure, therefore, the gain of an unselected microphone is generally left unchanged. Gains of selected microphones, e.g., microphones that have speech energy of good strength, are adapted in accordance with the gain computation of their respective AGC loops.

It is possible that unselected microphone(s) have speech signal levels similar to a selected microphone. This can happen, e.g., when the person that is speaking is also moving about the conference room, traversing the space between multiple microphones. In order that smooth handover take place between microphones, per techniques of this disclosure,

microphones with speech energies similar to a selected microphone have their gains adapted per their AGC loops. In this manner, even as the person walks out of the range of a selected microphone (leading to its eventual deselection), another microphone, whose signal that was low until now but rising to the point of selection, already has an active AGC loop tracking the voice of the approaching person.

CONCLUSION

In situations where multiple microphones are distributed across a room, e.g., in a conference or recording room, techniques of this disclosure describe automatic gain control for the set of microphones. AGC is performed such that an even speech output level is generated, e.g., weak voices amplified and strong voices attenuated, without sudden or large fluctuations in AGC levels, and without other audio artifacts arising out of AGC adaptation.