Title : Wind Noise Mitigation via Dynamic Microphone Selection

Inventors: Syavosh Zadissa (Meta Platforms Technologies, LLC), Gongqiang Yu (Meta Platforms Technologies, LLC), Xiaoxue Li (Meta Platforms Technologies, LLC)

Problem Statement:

The recent study of the wind noise data suggests wind noise suppression (WNS) algorithms face the largest challenge from wind noise coming from right in front of the user. As a result, the audio quality as a result is significantly worse than all other directions. This study also shows the wind noise does not contaminate all the mics equally, due to the shape of the mic array. Assuming we have some mechanism to detect the most contaminated mics and exclude them from beamforming, the output audio would be significantly improved.

Solution:

Therefore, we created a strategy for an audio system to handle the most challenging case with a detector for wind noise coming from the front. Upon the detection, an audio system switches to a different subset of the microphones to apply WNS, beamformer and the following processing modules.

Strategy to Mitigate Wind Noise in The Most Challenging Case

A recent study of wind noise data suggests that wind noise suppression (WNS) algorithms face the largest challenge from wind noise coming from right in front of the user, and the audio quality as a result is significantly worse than all others. This study also shows the wind noise does not contaminate all the mics equally, due to the shape of the mic array. This finding offers a possibility that we can exclude the mic channels mostly dominated by wind noise to improve the output audio quality. Therefore, we created a strategy to handle the most challenging case with a detector for wind noise coming from the front. Upon the detection, we switch to a different subset of the mic channels to apply WNS, beamformer and the following processing modules.

Front Wind Detector

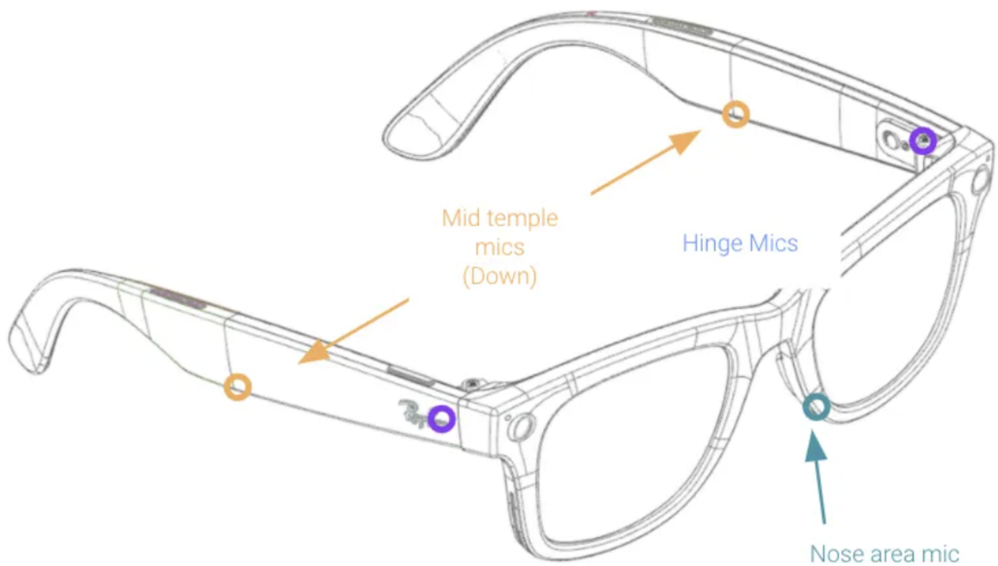

Figure 1. The geometry of the mic array on a headset

The headset is equipped with five microphones, as marked in the figure above. We have wind noise data collected in the lab, from various directions relative to the mannequin wearing the glasses. The relative difference of the wind noise power among the microphones is the most relevant indicator for determining the directions. For wind coming from the front, the two hinge mics have a similar level of noise power, which is significantly higher than the mid temple mics. We didn't see the behavior on wind from any other direction, thus it can be used to infer the presence of the wind from the front.

In some embodiments, the WNS includes a noise power estimator and a wind noise presence probability If wind noise were detected, the audio system may check 1) whether the hinge mics have significantly larger noise power than the temple mics; 2) whether the noise power between the two hinge mics are at the same level. With both conditions met, the audio system detects the front wind. A hangover variable is used to stabilize the detection, which counts the number of consecutive frames with the conditions met. Its value will be decreased otherwise, and reset when the wind goes off. Additional steps determine the point at which we are confident the wind is off.

The existence of the ambient noise and other sound sources might impact the detection, as such the threshold for the two conditions is chosen carefully. Fortunately, the higher the wind speed is, the more dominant the wind noise will be. Thus the detector may become more robust for higher wind, as well as more helpful.

Automatic Switch of Microphones

For the assistance path, by default, the audio system takes the audio signal received by the nose mic and hinge mics, applies the signal enhancement, and outputs the beamformed audio towards the user's mouth. The mid temple mics are mostly used for video capture. However, the hinge mics have much lower signal to noise ratio and worse intelligibility than the temple mics, when front wind is present. In this embodiment, upon the detection of front wind, the temple mic signal may replace the hinge mics to work with the reference mic for estimating the suppression gains. And the beamforming may be performed on this new subset of mic inputs. In some embodiments, another set of beamforming coefficients is used for the combination of nose mic and the temple mics in the resources. In some embodiments, an API notifies the beamformer when to make a switch.

Results and Demos

The proposed method was tested in a Matlab pipeline on the wind noisy data collected on POC3. The front wind detector is robust to make the correct detection when tested with wind from various directions and the no-windy situation. The audio quality on the recordings mixed with front wind was evaluated. WW detection rate and the STOI scores are tested as well, and the results are presented below. For wind speed at 3 m/s and 5 m/s, there is great improvement in the intelligibility, and for wind at 8 m/s, the WW detection rate has improved significantly.

Table 1: WW detection rate

	3 m/s	5 m/s	8 m/s
Before	99.5%	96.0%	18.5%
After	99.5%	97.3%	61.2%

Table 2: STOI scores

	3m/s	5m/s	8m/s
Before	0.76	0.52	0.33
After	0.87	0.66	0.40

Appendix:

The control flow of the front wind detector is as below