Noise reduction for media streams

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Introduction

In the Hearing at Home project the central "Home Information and Communication" (HIC) platform is developed to support hearing-impaired persons in home environments (for more information about the project see [1]). Easy to configure "Supportive Audio Signal Processing" (SASP) is available using the Master Hearing Aid (MHA) [2] as a real-time audio-signal-processing framework. Also visual support on a TV screen with a synthetic face ("Synface") [3] for lip reading is included. Amongst other, individually configurable algorithms, several algorithms can be used for noise reduction of the media streams without individual fitting to enhance the accessibility of the presented audio materials. It will be possible to classify the acoustic situation in the media stream automatically in real-time using six classes allowing to activate the appropriate noise reduction strategies. In user tests the performance of three algorithms is evaluated.

The HIC-platform

In the HIC-platform home information, home entertainment, home automation and home care applications are combined. In figure [1] examples of connections and applications are shown, e.g. Telephone, TV or the doorbell. An easy to handle remote control gives access to the system using a standard TV-screen.

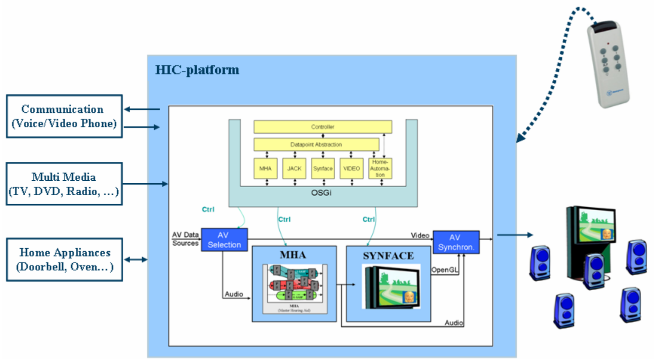

Figure 1: Overview of the HIC-platform with examples of connections (Telephone, TV, doorbell) and a remote control and TV-screen

Figure 2 shows the possibilities of the audio signal flow in the HIC-platform: In the right column the individual Supportive Audio Signal Processing (iSASP) is done. Individually configurable and with an easy fitting routine combined algorithms for compression of dynamics to compensate hearing loss is done. In the left column the global (gSASP) Supportive Audio Signal Processing can be found: It will be possible to classify the acoustic situation in the media stream automatically in real-time using six classes allowing to activate the appropriate noise reduction strategies:

(1) Single-channel noise reduction according to Ephraim-Malah together with a speech pause detector,

(2) stereo noise reduction additionally removing the central signal in a control path ("left minus right" = noise estimation, also for non-stationary noise),

(3) frequency shaping noise reduction by emphasising a frequency range important for speech intelligibility (also used if classifier does not give clear result)

(4) time-varying attenuation and

(5) noise reduction by selection of channels.

In user tests the performance of algorithm 1-3 is evaluated: Results of sound quality assessment, listening effort estimation and speech intelligibility measurements with hearing impaired subjects from groups with different types of hearing impairment are shown in the result part.

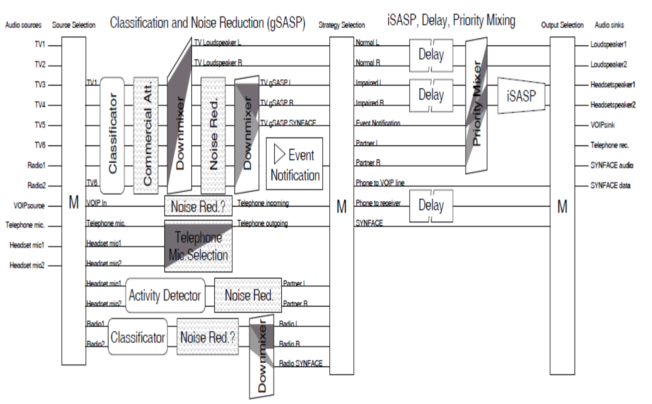

Figure 2: Example of information flow in the HIC-platform: Several inputs can be chosen and processed using global (gSASP) and individual Supportive Audio Signal Processing (iSASP)

Measurements

At three sites and with four groups of hearing impaired subjects three parts of Measurements have been done:

(1) Sentence tests measuring speech intelligibility

- Germany: Oldenburger Satztest
- Sweden: Hagerman Test
- Netherlands: Plomp Test

(2) Listening effort scaling

- Matlab® -Tool

(3) Paired comparison

- Matlab® -Tool

All Sentence-tests are used as modules in Oldenburg Measurement Applications. All signal processing during the measurements has been done in real-time using the MHA.

Four noise signals have been chosen to be mixed with different speech signals and to be processed by the three algorithms:

(1) Speech with stationary noise: single-channel Ephraim-Malah algorithm

(2a) Speech with babble noise and (2b) speech with traffic-noise: two-channel Ephraim-Malah algorithm

(3) Speech with action movie: frequency shaping algorithm

(1) Speech intelligibility

To measure the effect of noise reduction the speech intelligibility has been measured at +1 dB (or higher) fixed SNR, depending on previously measured, individual SRT (50% speech intelligibility). Speech in all 4 noise signals with and without noise reduction has been tested.

(2) Listening effort scaling

The subjects have been asked: "How exhausting is it to understand the speech?" On a quasi-continuous numerical rating scale with six anchor categories on a Matlab®-GUI the subjects have to give their answers. The same four noise signals as in Measurement 1 have been used; as speech two male and two female speakers have been taken, so that there have been four ratings per condition. The signals have been presented in a randomized order. Subjective level adjustments to adjust loudness to be optimal with respect to the perceived listening effort has been done to make sure that there is no impact of loudness on the rating.

(3) Paired comparison

The overall preference has been rated: Subjects were asked to indicate which signal they would prefer to listen to for a longer time: They could listen to and then choose either the processed, noise-reduced signal or the unprocessed signal.

Results

The first results from the three sites have been collected:

(1) Speech intelligibility

Figure 3 shows the difference in percentage between the two measurements, where one has been done with noise reduction and the other has been done without noise reduction. Positive values mean that the speech intelligibility is higher without noise reduction. For the group (HI) from the Netherlands there is a degradation of speech intelligibility visible. This data needs to be analysed further. For most of the cases no significant difference can be found.

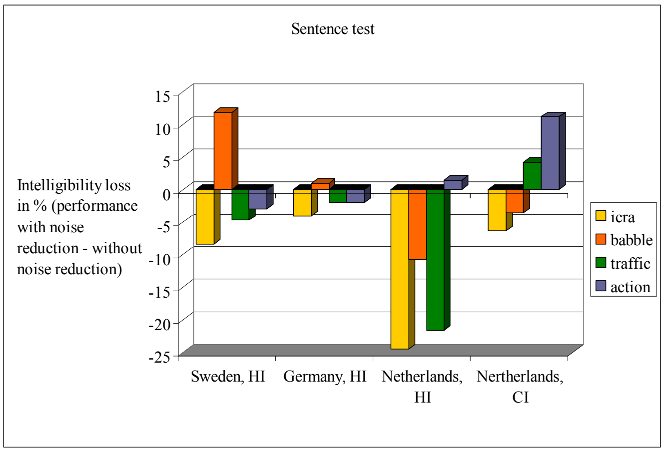

Figure 3: Results of speech intelligibility measurements: Shown is the difference of two measurements of speech intelligibility in percentage. Positive values mean a benefit of speech intelligibility with noise reduction. Shown are the results of the four subject groups and the four noise signals.

(2) Listening effort scaling

The mean values of the ratings for all conditions and test sites are shown in Figure 4. Low values indicate that there is a low listening effort (to understand the speech). High values indicate that it is rated very hard to understand the speech. For a few cases significant differences can be found where the effort has been rated higher for the presentation with noise reduction as the presentation without noise reduction. For the most cases only small differences can be found.

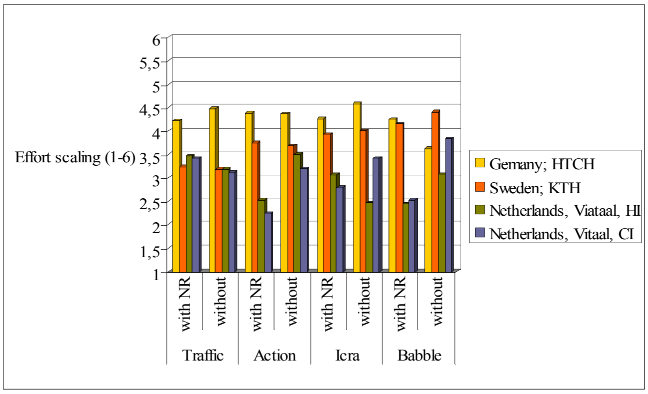

Figure 4: Results of listening effort scaling measurements. Higher values mean that the effort is rated higher.

(3) Paired comparison

The results of the paired comparison measurements are shown in Figure 5: Shown is the preference of the processed, noise reduced signal. A significant preference at all sites is found for the stereo noise reduction of the babble noise.

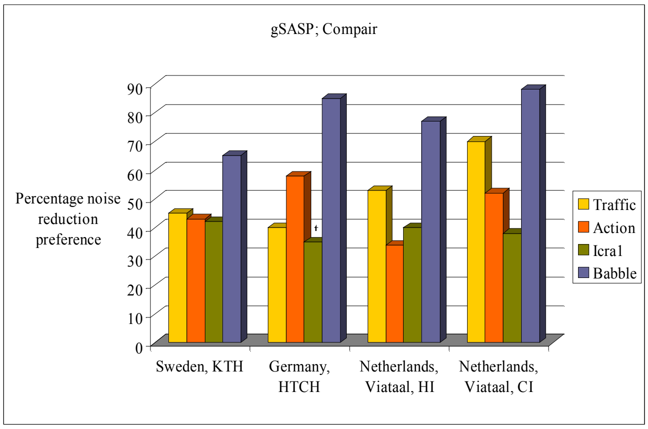

Figure 5: Results of paired comparison measurements: 100% would mean that all subjects preferred all signals in the processed, noise reduced way.

Conclusion

Three algorithms for noise reduction have been tested in three types of measurements: The investigation of details in the measurements of speech intelligibility has to confirm that there is no advantage of noise reduction as expected for this type of algorithms. In the listening effort scaling the overall result does not show a difference. An advantage of noise reduction would have been considered possible. In the paired comparison measurements the babble noise, processed with the stereo noise reduction, is clearly preferred by the subjects at all sites.

In a next study the classifier for automatic noise reduction algorithm selection will be tested. The other two additional noise reduction strategies will be included: The time varying attenuation and the emphasis of centre channel in 5.1 broadcasts. This study will give further information about the user acceptance of the noise reduction part of the HIC-platform.

References

[1] Reference to the Hearing at Home project. URL: `http://www.hearing-at-home.eu`

[2] Grimm, G., Herzke, T., Berg, D., Hohmann, V., The master hearing aid – a PC-based platform for algorithm development and evaluation. *Acta Acustica united with Acustica* 92 (2006) 618-628.

[3] J. Beskow, I. Karlsson, J. Kewley, and G. Salvi: "SYN-FACE - A Talking Head Telephone for the Hearing-impaired.", in K. Miesenberger, J. Klaus, W. Zagler, and D. Burger (eds.), Computers helping people with special needs, pp. 1178-1186, 2004.