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GABROVO

EVALUATION OF INFLUENCE IMPULSE RESPONSE AND BABBLE NOISE ON INTELLIGIBILITY OF SPEECH IN AMBIENT OF LECTURE HALL USING STOI ALGORITHM

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Abstract
The first part of the paper describes the intelligibility of speech, influence of impulse response in the lecture hall and classroom, babble noise (BN16) and the signal to noise ratio (SNR). The second part of the paper presents experiment, the results of experiment, provide by tested sentences from Serbian Matrix Sentence Test (SMST) base with objective method using STOI algorithm. Results of experiment were shown in tabular and graphical form. After a comparing the results with the results of similar tests the conclusion has been brought.

Keywords: intelligibility, SMST, STOI, babble.

INTRODUCTION

Speech communication is a bidirectional process consisting of a sender who transmits a message, and a recipient who processes it and provides response. When an audio message travels through a communication channel, interference can negatively impact on how clearly it is recognize. Intelligibility measures how clearly speech can be recognize under specific conditions. Background noise can very impair communication clarity and manifests in many different ways, including: street traffic [1], industrial noise [2], wind [3], rain [4], simultaneous group chatter (babble noise) [5], room reverberation [6] and echoes, signal distortion etc. In aim to determine the intelligibility of speech in different evoirment and conditions, the researchers using test with two type of words with meaning [7] or without meaning-logatom [8], and two type of sentence: sematically corect [9] or syntactically defined [10]. This paper analyzed the influence of early reflections, babble noise of 16 speakers (BN16) on speech intelligibility in the Serbian language, using matrix sentences, obtained from the SMST base [11] in the space of lecture hall - amphitheater. Analysis of amphitheater dimensions across higher education institutions reveals a lack of standardized sizes, mostly because of variations in architectural shapes and spatial constraints, and there are no uniform sizing standards [12]. The experiment was performed in the Amfiteather "A2" on Academy of Technical and Educational Studies Niš, Serbia, using an objective test method, STOI test, using STOI algoritham. The resulth intelligibility of sentence was determined by the SI_{STOI} coefficient which goes in range from 0 ÷ 1, where 0 is absolute inintelligibility and 1 is absolute intelligibility. Comparing obteined results with the results of similar tests [13] and standards [14] the conclusion of intelligibility was brought.

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The organization of work is as follows. Section II experiment, results and analysis of results of experiment. Section III is the conclusion.

EXPERIMENTAL RESULTS AND ANALYSES

This section presents the experimental procedure testing intelligibility, the results of the experiment, and their analysis.

Experiment

On Fig.1. block diagram of realization of experiment was given.

For realization experiment first the bases were formed:

a). speech signal obtained with the help of the computer from the Serbian Matrix Sentence Test (SMST) database,

b). forming base of room impulse response (RIR),

c). forming babble noise from sixteen people BN16 (8 male and 8 female).

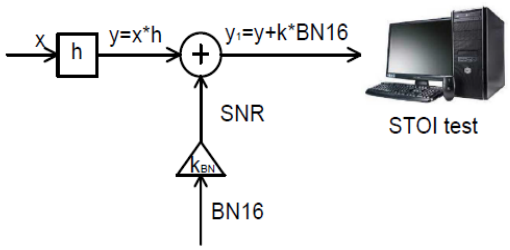


Fig 1. *Block diagram of experiment*

After we obtained sentence from SMST base $\boldsymbol{x}$, the speech signal is generated in the way that is performed by convolution with impulse response $\boldsymbol{y}$. Such a signal was superpromesed with babble noise BN16, and the different value SNR = {-10, 0, 10, 20, 30, 40, 50} dB, which defines the parameter $\boldsymbol{k_{BN}}$.

Generated speech signal with impulse response, babble noise and predefine value of SNR, $\boldsymbol{y_1}$, was test with STOI algorithm, to determinate intelligibility of speech using SI_{STOI} coefficient.

Results

The results of experiment was given in tabelar and graph form. In Tab. 1 and Fig. 2 are shown the results of testing with STOI test, depending from measure point and SNR.

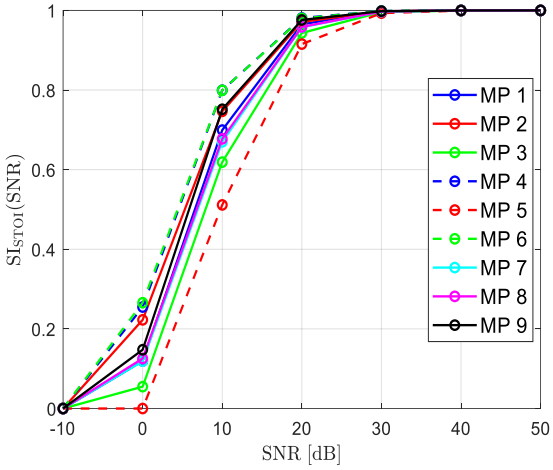


Fig. 2*. Intelligibility of sentence, STOI test for SNR= -10dB ÷50dB and nine measure point (MP 1÷ MP 9)*

The following figures from 3 ÷ 7 give the spectral characteristics of intelligibility for measure point from MP1 to MP9 and variable value of SNR: a) SNR= -10dB; b) SNR= 0dB; c) SNR= 10dB; d) SNR= 20dB; e) SNR= 40dB; f) SNR= 50dB. Simbol S represent the speaker.

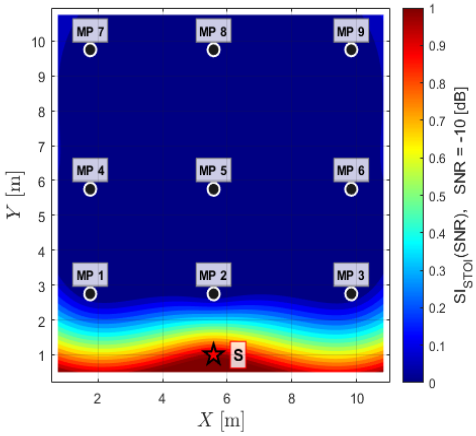


Fig. 3. *Intelligibility of sentence, STOI test for SNR= -10dB and MP 1÷ MP 9*

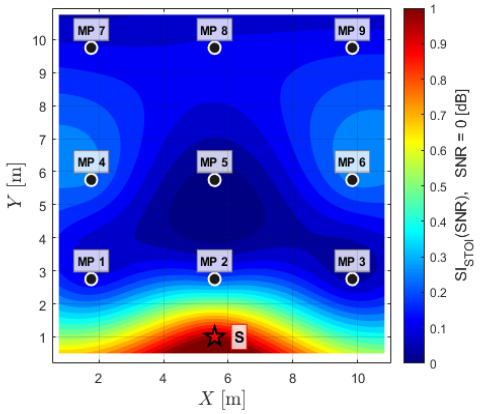


Fig. 4. *Intelligibility of sentence, STOI test for SNR= 0dB and MP 1÷ MP 9*

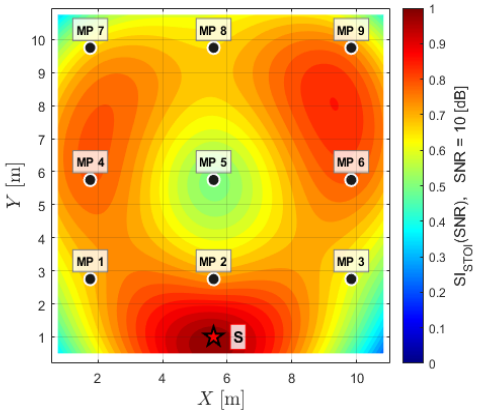


Fig. 5. *Intelligibility of sentence, STOI test for SNR= 10dB and MP 1÷ MP 9*

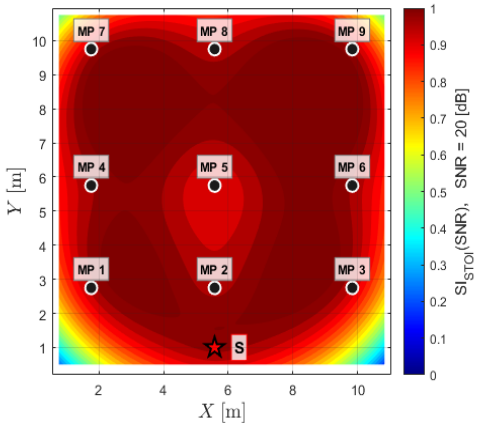


Fig. 6. *Intelligibility of sentence, STOI test for SNR= 20dB and MP 1÷ MP 9*

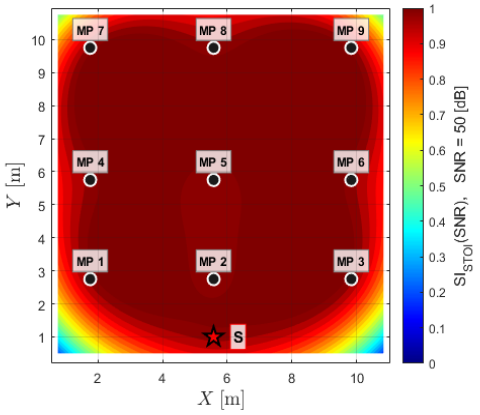


Fig. 7. *Intelligibility of sentence, STOI test for SNR= 50dB and MP 1÷ MP 9*

Table 1: Sentence intelligibility for different measure point for variable value of SNR

Intelligibility (coefficient SI_{STOI})									
SNR	**MP1**	**MP2**	**MP3**	**MP4**	**MP5**	**MP6**	**MP7**	**MP8**	**MP9**
-10	0	0	0	0	0	0	0	0	0
0	0.1195	0.2227	0.0549	0.2549	0	0.2657	0.1189	0.1257	0.1477
10	0.6994	0.7464	0.6189	0.7994	0.5114	0.7993	0.6698	0.6773	0.7517
20	0.9651	0.9710	0.9433	0.9810	0.9154	0.9799	0.9579	0.9586	0.9760
30	0.9974	0.9978	0.9958	0.9985	0.9931	0.9983	0.9969	0.9971	0.9980
40	0.9998	0.9998	0.9996	0.9999	0.9994	0.9998	0.9997	0.9998	0.9998
50	1	1	1	1	1	1	1	1	1
μ	0.6830	0.7054	0.6589	0.7191	0.6313	0.7204	0.6776	0.6798	0.6962

Analysis of the results

Analyzing the results of the experiment for SNR = {-10, 0, 10, 20, 40, 50} dB shown in Tab.1 and in the Fig.2 the conclusions about the intelligibility of speech it comes to the next conclusion:

a) based on the results of the experiment, it can be noticed that the intelligibility ranges goes from 0 ÷ 1.

b) analyzing the results shown for the mean value $\boldsymbol{\mu}$, in table 1 based on measure point (MP) the conclusion that the intelligibility of sentences goes in range from 0.6313 ÷ 0.7204.

Comparing the obtained results with the standard IEC 60268-16:2020, it is concluded that the intelligibility (in percent) belongs to the classification from: bad (0÷89), poor intelligibility (89÷ 92), fair (92-95), good (95-96), exellent (96-100).

By comparing with the international standard IEC 60268-1660268-16:2020, it is concluded that the quality of intelligibility and sentence is:

a) bad for SNR = {-10, 0, 10} dB;

b) poor for MP5 and SNR = 20dB;

c) fair and good for other MP and SNR = 20dB;

d) exellent for SNR = {40, 50} dB.

Based on values of mean value $\boldsymbol{\mu}$, quality of intelligibility and sentence is classificate in category of bad intelligibility (0÷89).

An analysis of the intelligibility results, taking into account the location of the measurement point relative to the speaker, leads to the conclusion that intelligibility is lowest at measurement point 5 (SI_{STOI} = 0.6312) and highest at measurement point 6 (SI_{STOI} = 0.7204).

CONCLUSION

In this paper, speech intelligibility using matrix sentences from the SMST base was tested in the presence of impulse response in combination with babble noise of 16 speakers, and values for SNR = {-10, 0, 10, 20, 40, 50} dB. The results were compared with the results similar tests [14]. Comparative analysis showed that the intelligibility of the speech signal is less in the presence of applause noise, which is explained by the distribution of energy in the spectrum. By comparative analysis of the obtained experimental results and classification from the standard IEC 60268-16:2020, it is concluded that intelligibility in all cases belongs to the class from bad to exellent intelligibility.

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