Incorporating Embedding Vectors from a Human Mean-Opinion Score Prediction Model for Monaural Speech Enhancement

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Motivation

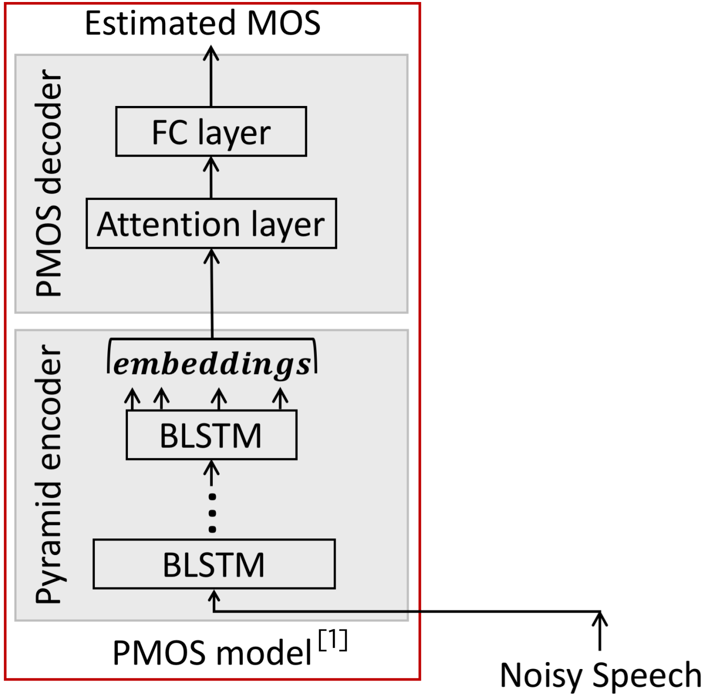
Speech Enhancement (SE) systems target maximization of speech quality and intelligibility measured by various proposed **objective functions**.

Current speech quality objective functions are often not strongly correlated with **human subjective evaluations**.

Automatic speech assessment that measures the subjective score of enhanced speech can help SE systems to estimate better perceptual quality speech.

Speech Quality Assessment Model

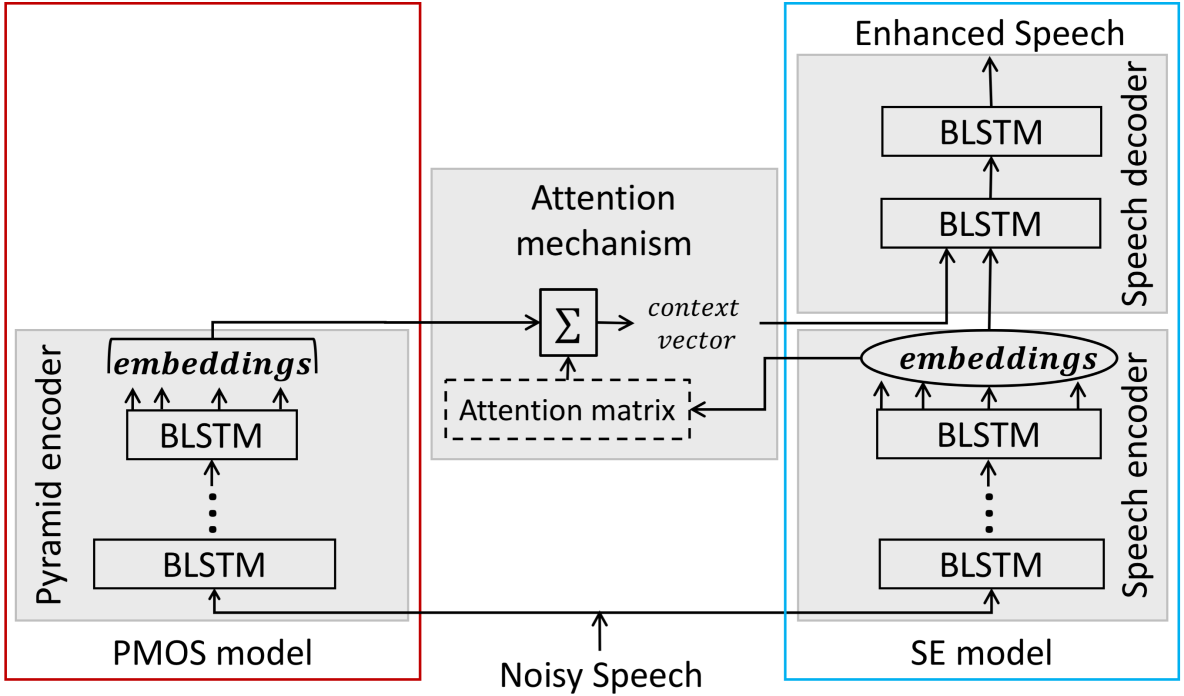
PMOS model



[1] X. Dong et. al, “A Pyramid Recurrent Network for Predicting Crowdsourced Speech-Quality Ratings of Real-World Signals,” in Proc. Interspeech, 2020.

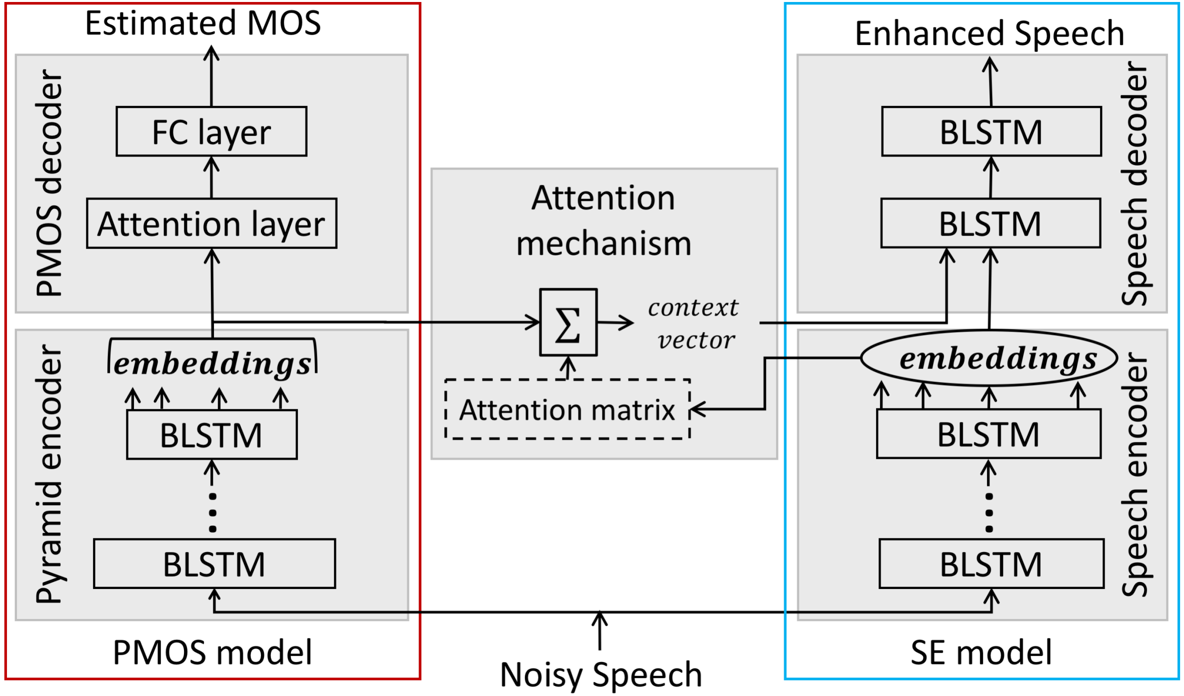
Attention-based SE Model

SE model



Joint-learning SE Model

SE + PMOS model



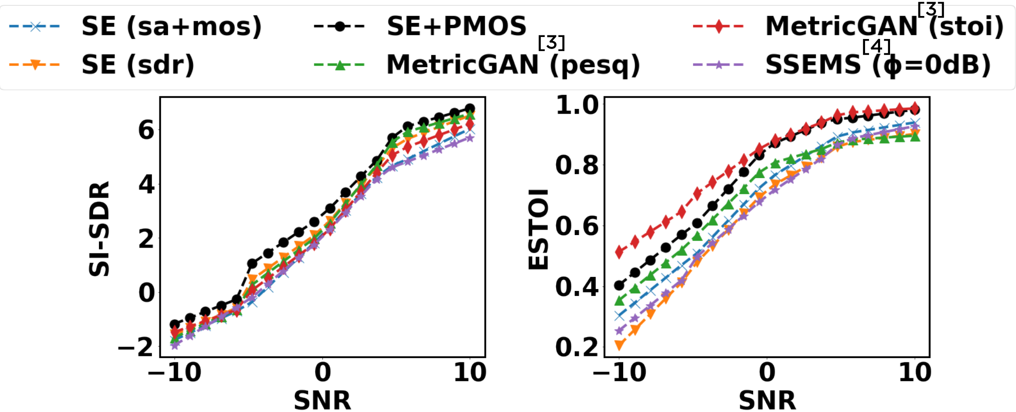
Results

Table 1: Performance comparison with MOS prediction models.

	MAE	RMSE	PCC	SRCC
NISQA[2]	0.62	0.7	0.71	0.79
PMOS [1]	0.51	0.57	0.88	0.88
SE+PMOS (proposed)	0.45	0.52	0.9	0.91

PCC = Pearson's correlation coefficient,
SRCC = Spearman's rank correlation coefficient,
SI-SDR = Scale-invariant signal-to-distortion ratio,
ESTOI = extended short-time objective intelligibility,

Figure 1: Average (a) SI-SDR, (b) ESTOI performance of SE models on test speech in different SNRs.



(a) SNR vs SI-SDR (b) SNR vs ESTOI

[1] X. Dong et. al, "A Pyramid Recurrent Network for Predicting Crowdsourced Speech-Quality Ratings of Real-World Signals," in Proc. Interspeech, 2020.
[2] G. Mittag et. al, "Non-intrusive speech quality assessment for super-wideband speech communication networks," in Proc. ICASSP, 2019.
[3] S.-W. Fu et. al, "Metricgan: Generative adversarial networks based black-box metric scores optimization for speech enhancement," in Proc. ICML, 2019.
[4] R. E. Zezario et. al, "Specialized speech enhancement model selection based on learned non-intrusive quality assessment metric." in Proc. Interspeech, 2019.

Results

Table 2: Average results of the SE models in different performance metrics.

		COSINE				VOiCES			
	Loss function	**PESQ**	**SI-SDR**	**ESTOI**	**MOS-LQO**	**PESQ**	**SI-SDR**	**ESTOI**	**MOS-LQO**
Mixture	-	1.46	0.53	0.62	4.04	1.26	-1.3	0.48	2.74
SE	mse	2.68	2.8	0.8	3.2	2.3	1.2	0.69	3.5
	mos	2.8	3.8	0.82	4.2	2.37	1.66	0.74	5.3
	mse, sa	2.72	3.1	0.82	4	2.35	1.6	0.7	3.8
	sa, mos	2.89	4.1	0.85	4.4	2.42	1.72	0.77	5.7
	sdr	2.7	4.5	0.82	4	2.32	2.01	0.72	4.5
SE+PMOS (proposed)	mse	3.1	4	0.85	4.2	2.48	1.8	0.8	6
	mse, sa	3.19	**4.6**	0.93	4.8	2.54	**2.08**	0.86	6.3
	mse, sa, mos	3.19	4.5	0.92	**5.1**	2.53	2.06	0.84	**6.5**
MetricGAN[3]	pesq	**3.28**	4.4	0.9	5	**2.67**	2.01	0.83	6.1
	stoi	3.19	4.3	**0.94**	4.8	2.5	2	**0.87**	5.8
SSEMS[4]	qnet (ϕ=0dB)	2.85	2.9	0.83	3	2.4	1.8	0.7	2.8

Conclusion

Our proposed **speech enhancement** model utilizes a speech quality **MOS assessment metric** in a joint learning manner.

Results show that proposed **SE+PMOS** model outperforms other models in different noisy environments.

We evaluate our model's subjective score using an **MOS- estimation model**.

Our assessment model provides **utterance-level feedback**, which may be sub-optimal since the model's embeddings are calculated at the frame level.

Thank You

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