BERT-ASR

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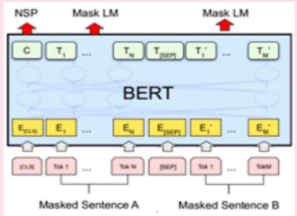
Overview

- A simple method for automatic speech recognition (**ASR**) by fine-tuning BERT
- **BERT-ASR**, formulates ASR as a classification problem, where the objective is to correctly classify the next word given the acoustic speech signals and the history words.

BERT

- **B**idirectional **E**ncoder **R**epresent**a**tions from **T**ransformers
- A language model (LM) trained on large-scale unlabeled text data and can generate rich contextual representations
- Learns language by using 2 main methods: **MLM** (Masked Language Model) & **NSP** (Next Sentence Prediction)
- Adopts a multi-layer Transformer encoder architecture



BERT-LM

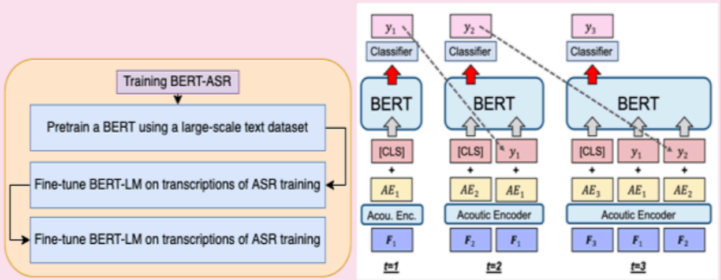
$$(y_1,\ldots,y_T) \rightarrow \begin{cases} ([\mathrm{CLS}]) \\ ([\mathrm{CLS}], y_1) \\ ([\mathrm{CLS}], y_1, y_2) \\ \ldots \\ ([\mathrm{CLS}], y_1, \ldots, y_{t-1}) \end{cases}$$

- A probabilistic **Language Model (LM)** using BERT
- Exhaustively enumerate all possible training samples
- Training becomes simply minimizing cross-entropy objective

$$\mathcal{L}_{\mathrm{LM}} = -\sum_{i=1}^{N}\sum_{t=1}^{T} P(y_t^{(i)} | [\mathrm{CLS}], y_1^{(i)}, \ldots, y_{t-1}^{(i)}).$$

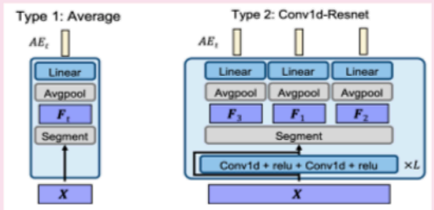
BERT-ASR Training and Fine-Tuning

- Acoustic frames can be segmented into T groups (T is # of tokens in transcript)
- Acoustic embeddings concatenated with original BERT inputs fed into model.
- This way we augment the BERT-LM into BERT-ASR



Acoustic Encoder

- Converts raw acoustic feature segments (Fi) into acoustic embeddings
- Authors experimented with the
  - ➢ **Average Encoder** and
  - ➢ **Conv1d-Resnet Encoder** (takes temporal relationship between segments into account)



Experiments

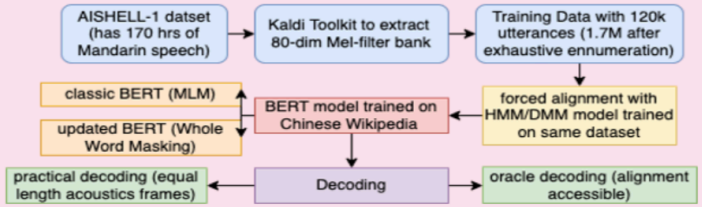


Table 1: Results on the AISHELL-1 dataset. "Orac." and "Prac." denote the oracle decoding and practical decoding, respectively. "Conv1d resnet X" denotes the conv1d resnet encoder with X resnet blocks. Best performance of the BERT-ASR are shown in bold.

Model	Acoustic encoder	Perplexity		CER (Orac.)		CER (Prac.)		SER (Orac.)		SER (Prac.)	
		Dev	Test	Dev	Test	Dev	Test	Dev	Test	Dev	Test
Trigram-LM	-	133.32	127.88	-		-		-		-	
LSTM-LM	-	79.97	78.80	-		-		-		-	
BERT-LM	-	39.74	41.72	-		-		-		-	
BERT-ASR	Average	5.88	9.02	65.8	68.9	96.4	105.8	60.3	63.5	91.5	100.3
	Conv1d resnet 1	4.91	7.63	55.8	59.0	89.6	99.6	50.0	53.8	84.4	94.1
	Conv1d resnet 2	**4.77**	**6.94**	**54.6**	**58.8**	89.7	**99.1**	49.5	53.6	84.6	93.5
	Conv1d resnet 3	4.83	7.41	54.8	58.9	89.8	99.4	49.6	53.6	84.6	93.9
	Conv1d-resnet 4	4.78	7.29	**54.6**	59.0	**89.5**	99.3	49.4	53.9	84.4	93.8
GMM-HMM	-	-		-		10.4	12.2	-		-	
DNN-HMM	-	-		-		7.2	8.4	-		-	

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