Improved Data Selection for Domain Adaptation in ASR

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Paper #4438
IEEE ICASSP 2021

Introduction

- We address domain adaptation in Automatic Speech Recognition (ASR) with semi-supervised training (SST).
- Data selection is critical with large domain shifts
- We use min. phone error rate for oracle selection; we approximate min. PER with the avg. phone confidence of an utterance.
- With larger domain shifts, deletions and low lexical diversity are serious issues; we address these by using the phone rate of an utterance in our selection metric
- We see up to 57% relative improvements over the baseline and good generalization across domain shift conditions.

Experimental Setup

Data

- We examine a dialectal domain shift from UK to US English, as well as additional simulated domain shifts: 8 or 16kbps mp3 compression, additive noise with an SNR of 0 dB or -10 dB, and reverberation.
- **Supervised data:** UK English, 100hrs, Conversational Telephone Speech (CTS) & voicemail
- **Unsupervised data:** US English, 400hrs, CTS
- **Test Set:** US English, CTS

Acoustic Modeling

- Our ASR models are hybrid TDNN-Fs, trained using the supervised & unsupervised data for 1 epoch of LFMMI, followed by 1 epoch of sMBR with the unsupervised data

Language Modeling

- We train trigram LMs using the supervised UK English data along with 62 million words of US English web data

Data Selection and SST

Confidence
Baseline

- Average word-level CTM confidence
- A common selection method in traditional (non domain shift) SST
- *confidence* = the posterior probability of a word or phone

$$\text{CTM Conf}_u = \frac{\sum_{i=1}^{W_u} \text{conf}_i}{W_u}$$

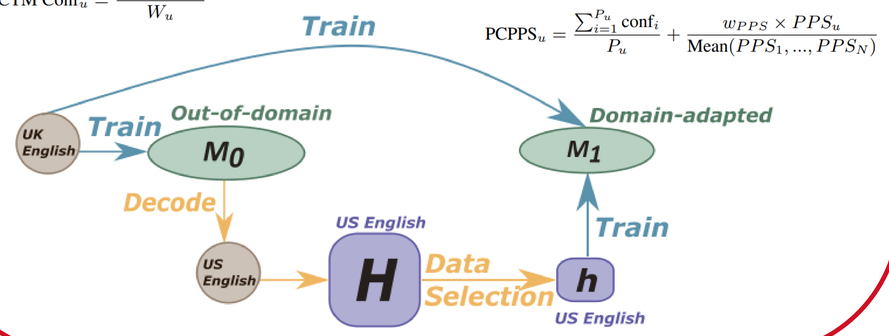
Minimum WER/PER
Oracle

- Utterances with the lowest Word or Phone Error Rate
- Oracle (cheating) selection method, used as an upper bound on SST selection performance

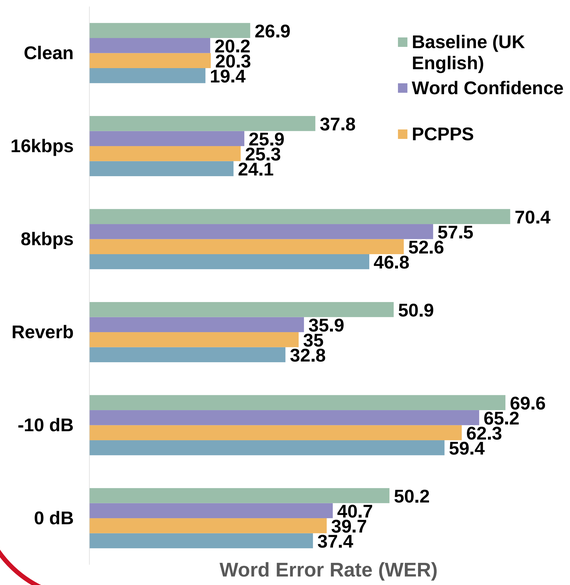
PCPPS
Proposed Method

- Average phone-level Cnet confidence, plus the phone rate (PPS) of the utterance
- PPS allows us to exclude high-deletion utterances
- Phone confidence is a closer approximation to acoustic error than word confidence

$$\text{PCPPS}_u = \frac{\sum_{i=1}^{P_u} \text{conf}_i}{P_u} + \frac{w_{PPS} \times PPS_u}{\text{Mean}(PPS_1, ..., PPS_N)}$$



Selection Methods Across Conditions



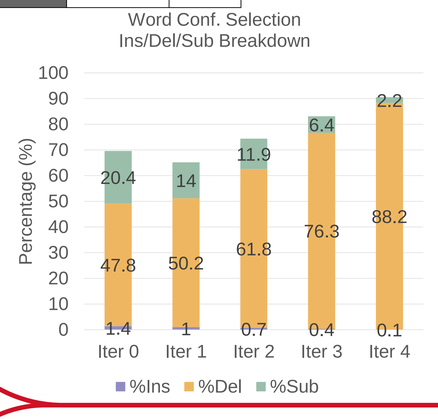
- PCPPS selection matches or outperforms word confidence selection across all six data conditions
- The performance gap between the two is most prominent where the domain shift is the greatest, such as the 8 kbps compression and noise conditions
- However, even PCPPS selection is unable to match oracle minimum PER selection, indicating that there is still room for improvement in data selection methods

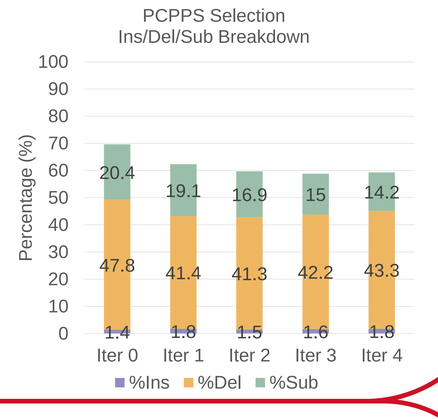
Lexical Diversity and Deletion Rates

Number of word types in a 31-hour data selection across 4 rounds of SST, using either word confidence or PCPPS selection, for -10 dB condition

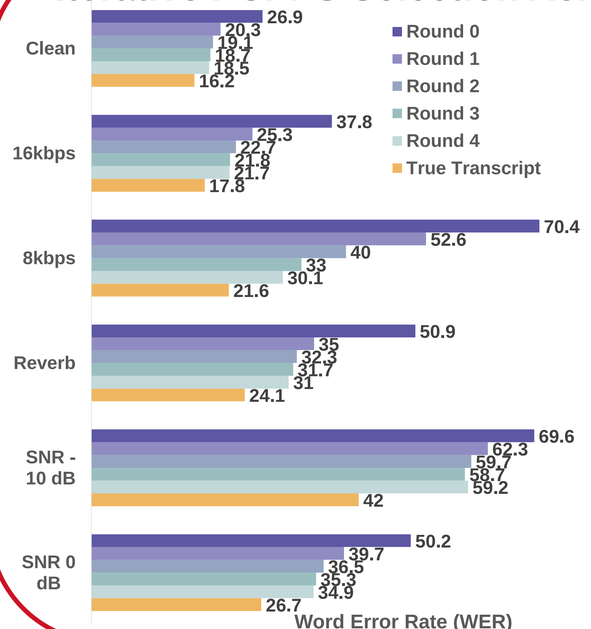
	Word Conf.	PCPPS
Random	6277	6277
Round 1	3459	8907
Round 2	266	8088
Round 3	92	7369
Round 4	78	7028

- Word Confidence Selection is degenerate when performed iteratively
- PCPPS Selection, in contrast, improves with each iteration of semi-supervised training
- Word confidence selection is biased towards utterances with low lexical diversity
- By the 4th Iteration of SST, the Word Confidence selection has only 78 unique words





Iterative PCPPS Selection Across Conditions



- PCPPS selection generalizes well across all 6 conditions
- After 4 rounds of SST with PCPPS selection, we see 15-57% relative improvements over the out-of-domain baseline model
- The "True Transcript" bars follow our typical SST setup, but use 100% of our target-domain audio along with their true transcripts, representing a lower bound on SST WER