Baseline Acoustic Models for Brazilian Portuguese Using Kaldi Tools

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Introduction

- Kaldi's new state-of-the-art hybrid approach (HMM-DNN) for ASR acoustic modeling has been successfully applied to many languages
  - English, German, Spanish, Italian, Arabic, ...
- Brazilian Portuguese (BP): the FalaBrasil group stands out in LVCSR using CMU Sphinx and HTK toolkits, however with HMM-GMM only

Problem

- Related works lack of solutions for BP using deep-learning techniques for LVCSR
- Apparently, no previous work has attempted to develop an HMM-DNN hybrid recipe for Brazilian Portuguese using Kaldi tools [1]

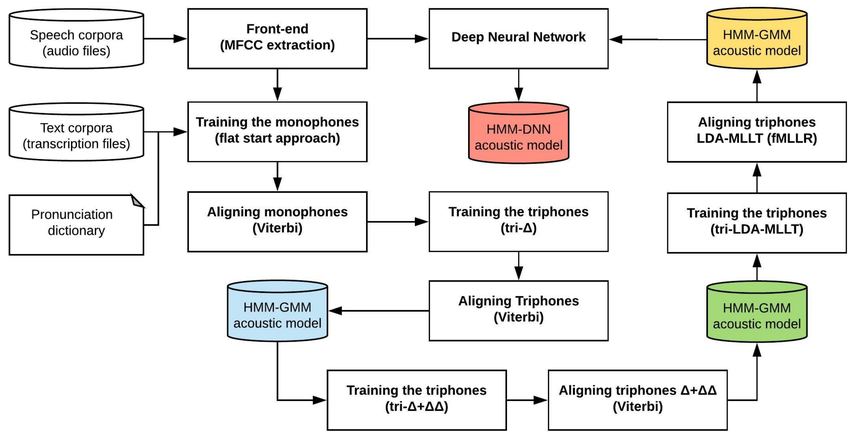
Solution

- A recipe adapted from the WSJ scripts is now publicly available at FalaBrasil group's GitLab repo (`https://gitlab.com/falabrasil`)

Building ASR Systems for BP

- Comparison between Kaldi and CMU Sphinx
- Audio corpora: ≈ 171h, 16 kHz mono WAV
- Language model: 3-gram trained with SRILM over CETENFolha text corpora (pp. ≈ 170)
- Phonetic dictionary: FalaBrasil's G2P software

Kaldi's Hybrid HMM-DNN Acoustic Model Training Pipeline



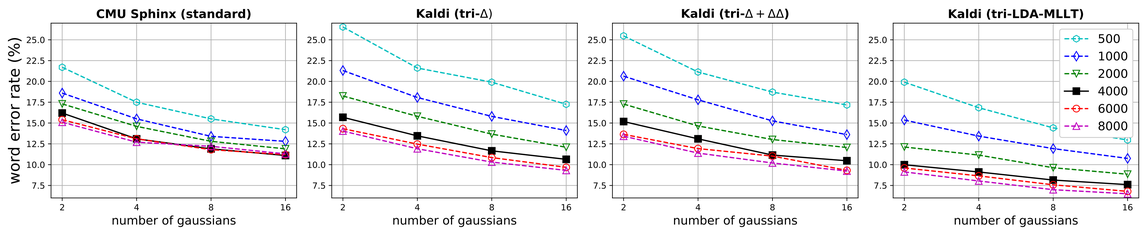
Experimental Tests Setup

- Tied-states (leaves or senones): 500 up to 8,000
- Gaussians per mixture (densities): 2 up to 16
- HMM-GMM triphone-based AMs were trained with both Kaldi and CMU Sphinx toolkits
- Re-estimation: CMU Sphinx uses Baum-Welch algorithm while Kaldi performs Viterbi training (which includes Viterbi alignment at each step)
- HMM-DNN hybrid model was trained on the top of Kaldi's best HMM-GMM model
- Hardware: HP EliteDesk 800 with Intel® Core™ i5-4570 CPU, 8 GB RAM and 1 TB disk storage

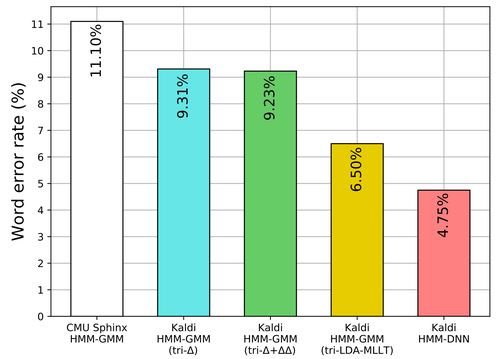
DNN Tools and Parameters

Tool or Param.	Value
DNN codebase	`nnet2` ("Dan's DNN")
Script	`train_pnorm_fast.sh`
Hidden layers	2
Activation function	p_norm
`pnorm_output_dim`	3,000
`pnorm_input_dim`	300
`num_epochs`	8
`num_epochs_extra`	5
Minibatch size	512
Learning rate	0.02 down to 0.004

Word Error Rate (WER) Results: Tied-states vs. Gaussians



Best WERs Comparison



Conclusions

- CMU Sphinx loses to Kaldi in WER even when comparing HMM-GMM models only, probably because of different re-estimation procedures (Baum-Welch vs. Viterbi)
- 57.21% improvement showed by Kaldi's HMM-DNN acoustic model over the best CMU Sphinx's HMM-GMM model

Acknowledgements

CAPES
FALA BRASIL

Reference

[1] D. Povey, A. Ghoshal, G. Boulianne, N. Goel, M. Hannemann, Y. Qian, P. Schwarz, and G. Stemmer, "The kaldi speech recognition toolkit," in *In IEEE 2011 workshop*, 2011.