Intelligent Voice Identification with Neural Networks

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CS 230 Final Project, Winter 2018

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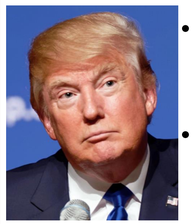
Motivation

Automated speech recognition is commonplace in dozens of technology domains. There are many potential applications for automated speaker recognition:

- Automated air traffic control
- Over-the-phone identity verification
- Speaker diarization for speech-to-text

Dataset

- **Audio clips of 17 people's voices**
- About 10 minutes of audio per person
- Audio collected from YouTube



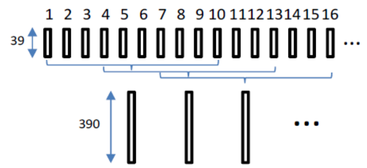
- Dataset breakdown: **95% train, 2.5% dev, 2.5% test**
- Per person: 9.5 min of training audio, 15s for dev, 15s for test

- Varying degrees of background noise
- Only one person speaking at a time
- Examples: Trump, Obama, characters from The Office

Pre-Processing

Mel-Frequency Cepstral Coefficients

- Need to represent data in a tractable way for a simple NN
- MFCCs are the standard in speech recognition tasks
- Derived from audio frequency content
- Modeled after human auditory system
- Extracted in sliding windows



Frame: 10 ms
Window: 10 frames
Stride: 3 frames

Uniformly scale audio amplitude

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Remove unvoiced audio with voice activity detection (VAD)

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Extract MFCCs and their derivatives for each window

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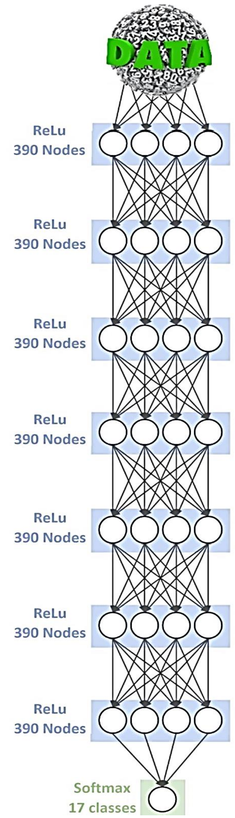
Normalize speaker feature sets

Architecture

Neural Network Parameters:

- 7 FC layers with ReLu activations
- Softmax output with 17 classes
- Run for 25 epochs
- Mini-Batch Size of 64
- Early Stopping with $\delta_{min} = 0,\ \ patience = 10$
- L2 Regularization with $\lambda = 0.7$
- Adam Optimization with $\alpha = 0.001,\ \beta_1 = 0.9,\ \ \beta_2 = 0.999,$ $learning\ decay = 0.00001$
- Batch Normalization with $Momentum\ = \ 0.99$
- Tuned hyperparams in space $N = [2,4,7,10],\ \ \lambda = [0,.1,.3,.5,.7,1],$ $L = [10,100,390,500,1000],$ $Batchsize = [16,32,64,256]$

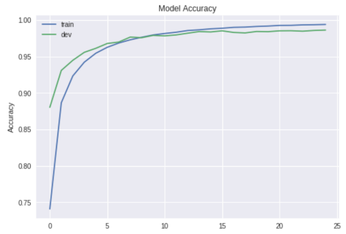


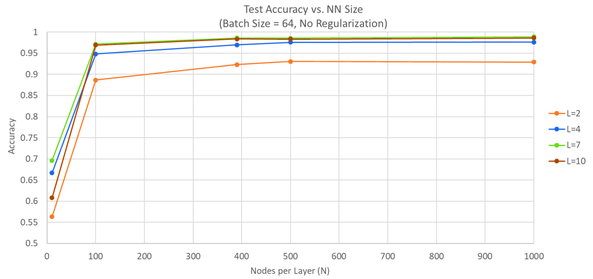
Results

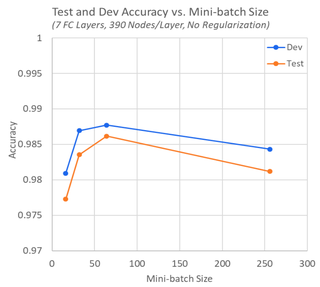
Accuracy on Dataset:

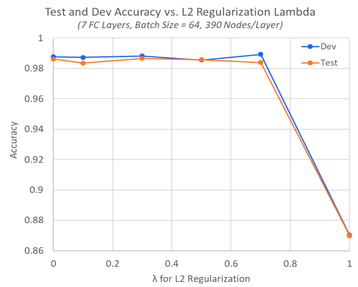
$Dev\ Accuracy\ = 98.64\%$

$Test\ Accuracy = 98.69\%$









Conclusions

- High accuracy over 17 speakers was achieved with an all FC layer architecture
- Small improvements in test accuracy were made through tuning of $\lambda_{L2}$and mini-batch size
- Asymptotic test accuracy behavior above ~400 nodes/layer and above ~7 hidden layers

Future Work

- Expand dataset to include more people
- Introduce "unknown" class
- Real-time speaker prediction
- Deeper hyperparameter search
- Automated sub-captioning

References

[1]: Z. Ge, A. Iyer, S. Cheluvaraja, R. Sundaram, A. Ganapathiraju, "Neural Network
Based Speaker Classification and Verification Systems with Enhanced Features," in Intelligent Systems Conference, London, UK, September 7-8, 2017.