Multimodal Machine Learning

Speaker identification

Vasileios Papadopoulos
Dimitrios Delikonstantis

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Motivation

- Speaker identification is the process of determining from which of the registered speakers a given utterance comes
- Speaker identification (in conjunction with speaker verification) is widely used in security systems
- The task of identifying a person by his voice becomes increasingly crucial with the development of IoT and technology
- Many applications require speaker identification
    - Biometrics authentication
    - Voice mail
    - Smart home

Dataset

VoxCeleb audio dataset

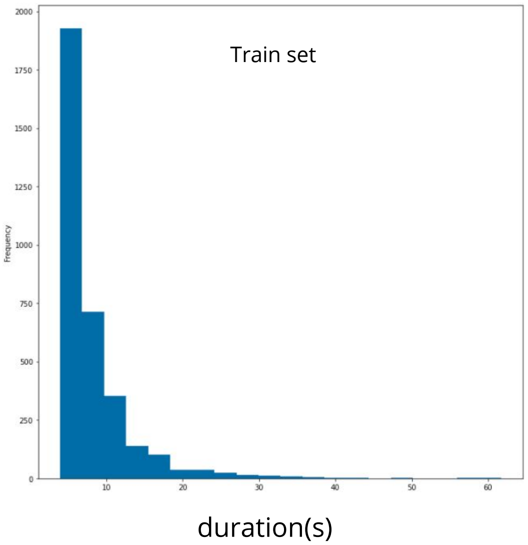
- Contains over 100,000 human speech utterances for 1,251 celebrities
- Spanning a wide range of different ethnicities, accents, professions and ages
- We focused only on **39** speakers with total of **4837** audio clips(computational issues)

Train/Test/Split

- For each speaker:
  - 70% audio clips kept for training
  - 30% testing
- Training set:
  - 70% train
  - 30% validation

Duration distribution

- Majority of clips have duration up to 10s.
- Sampling rate is 16KHz



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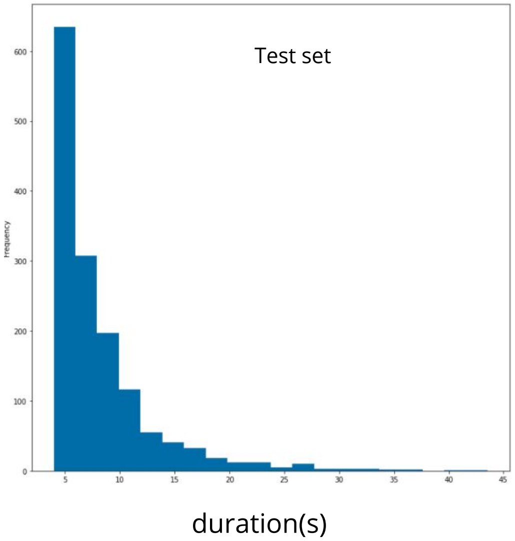
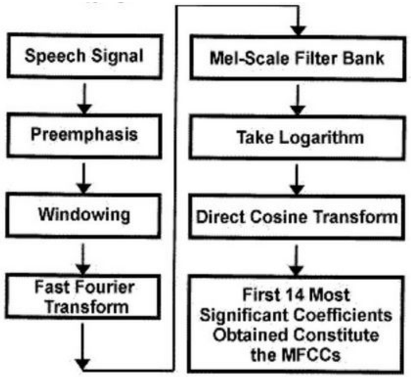


Shortest clip: **3.9(s)**

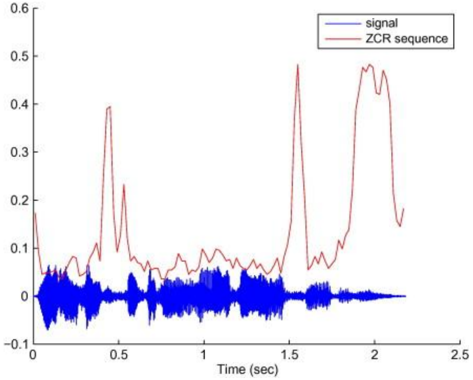
We use the first **2s** of each clip.
Assumption: no silence at the beginning.

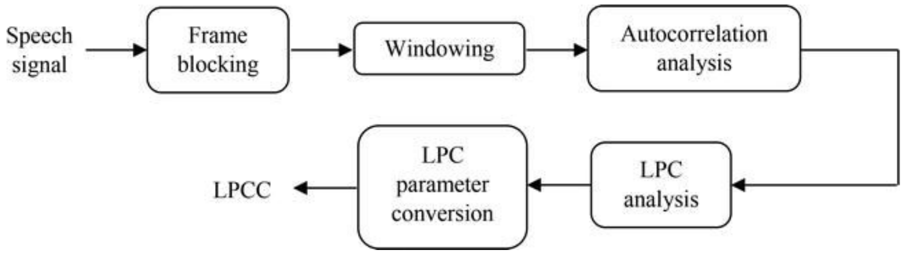
Feature extraction

- Mel-frequency cepstral coefficients (MFCCs)
  - Short-term representation power spectrum of a sound
- Zero-crossing rate (ZCR)
  - Rate at which a signal changes its sign from positive to negative or vice versa
- Linear Prediction Coefficients (LPC)
  - Future values of a discrete-time signal are estimated as a linear function of previous samples



Speech Signal → Preemphasis → Windowing → Fast Fourier Transform → Mel-Scale Filter Bank → Take Logarithm → Direct Cosine Transform → First 14 Most Significant Coefficients Obtained Constitute the MFCCs



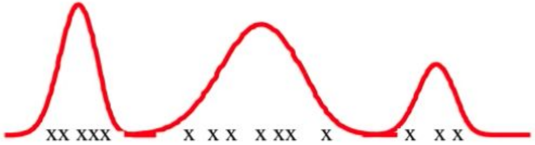


Speech signal → Frame blocking → Windowing → Autocorrelation analysis → LPC analysis → LPC parameter conversion → LPCC

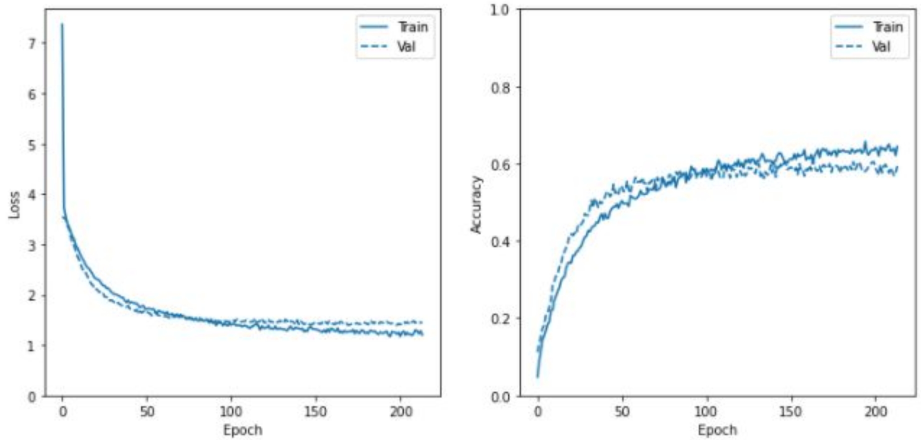
Models

- “Deep” Neural Network (113K parameters)
    - 5 Dense layers
    - 0.3 dropout
    - Softmax
    - Categorical_crossentropy
    - Adam optimizer
    - Early stopping
- Gaussian Mixture Models
    - For each speaker Σ(<mfcc,zcr,lpc>) (cluster) model as Gaussian Distribution
        - Not just by their mean(K-means)
    - Gives probability model of X
    - Perform statistical inference
        - Assign data to cluster with some probability

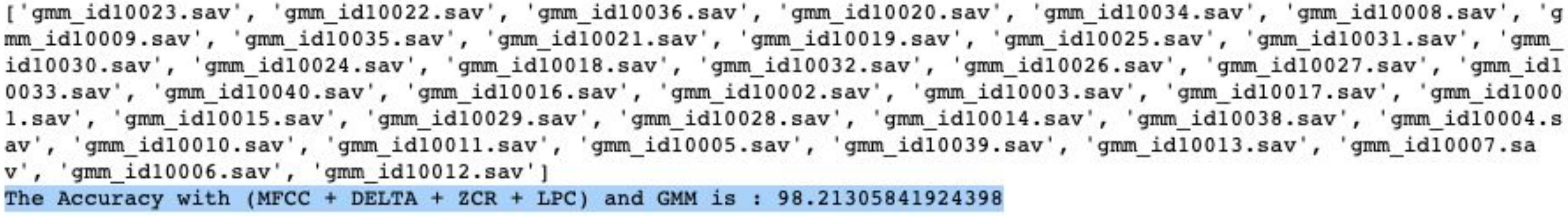
Practically, a multi-class problem with 39 classes(speakers)



Results



- Model underfits.
- Too simple.
- Deeper architecture required



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The Accuracy with (MFCC + DELTA + ZCR + LPC) and GMM is : 98.21305841924398
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Demo

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Conclusions

- We combined 3 widely used features for speaker identification.
    - GMM performed well on tiny dataset
    - NN-tuning required
- The combination of features seem to work for identification tasks but it is unclear(to us) whether could be useful for ‘similarity’ tasks.

Future work

- Work with entire vox celeb dataset
- Measure euclidean distance of features in hyperspace
    - Assumption: similar speakers will be closer
- Measure cosine similarity of features in hyperspace
- Type of Auto-encoder
- Combination of different feature extraction methods