Text-Independent Speaker Verification Using 3D Convolutional Neural Networks

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Task Definition

The Speaker verification problem refers to verifying the claimed identity of a speaker by using their voice characteristics. Our speaker verification system consists of three phases:

- Development Phase
  - Training 3D CNN
  - Discriminative Feature Extraction
- Enrollment Phase
  - Codebook formation
- Evaluation Phase
  - Speaker Identification
  - Speaker Verification

Implementation Details

Data Representation:

Typical MFCC Pipeline:

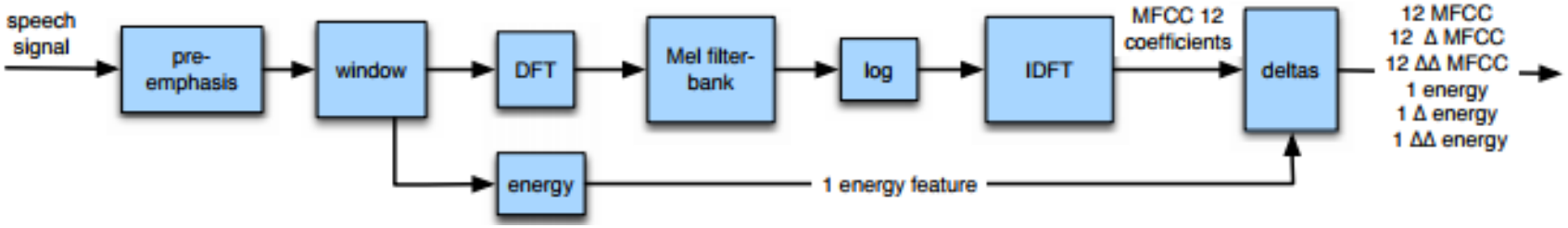


Image Source : D. Jurafsky, J. H. Martin, Speech and Language Processing

Implementation Details

Data Representation:

Modified MFEC Pipeline:

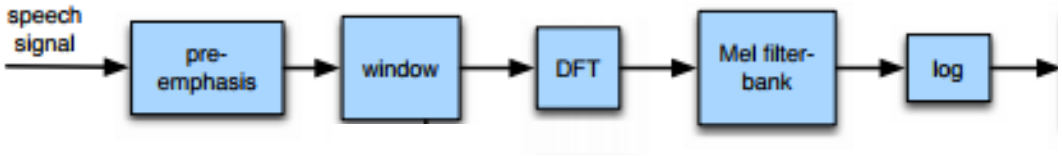
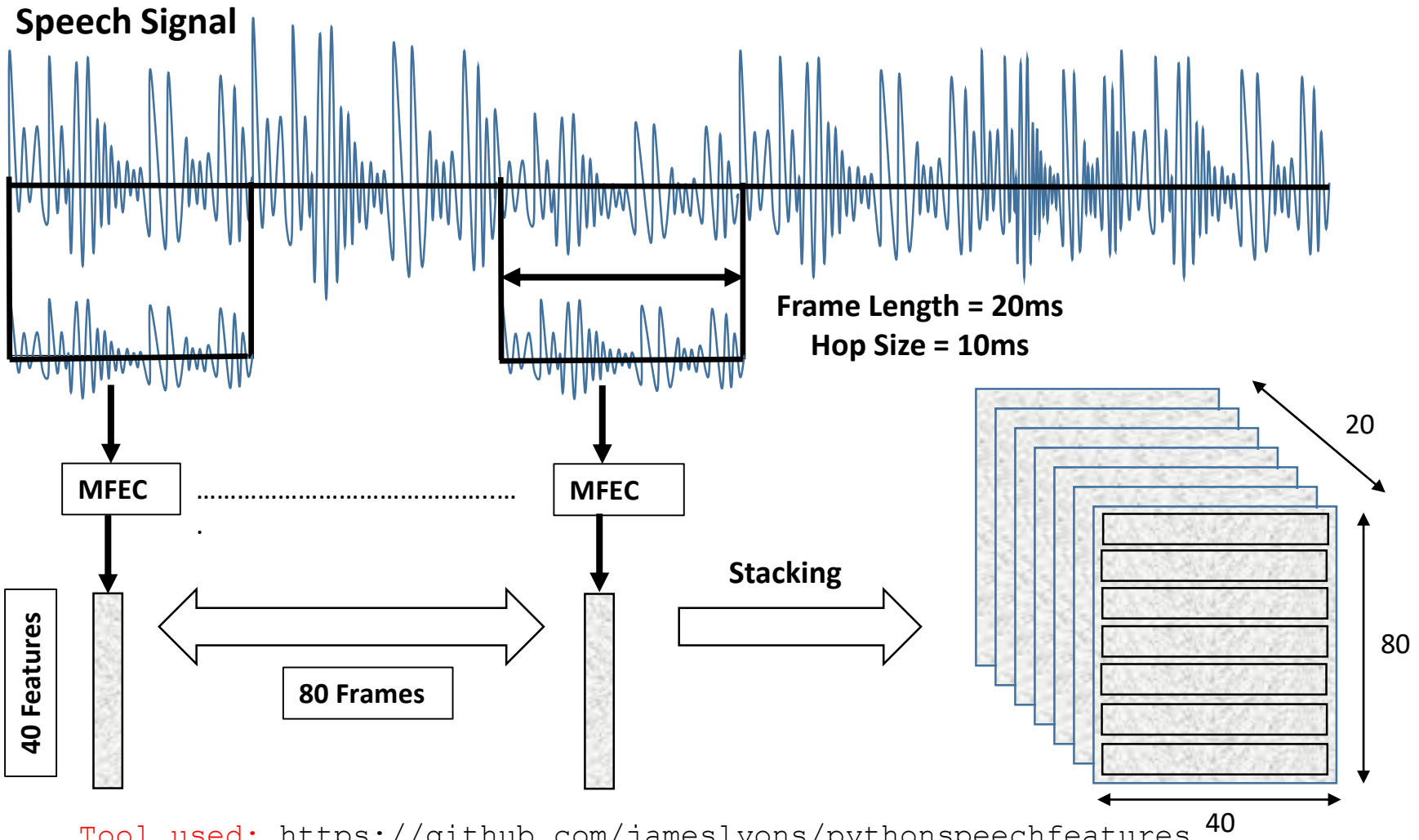


Image Source : D. Jurafsky, J. H. Martin, Speech and Language Processing

Implementation Details

Data Representation:



Tool used: https://github.com/jameslyons/pythonspeechfeatures

Implementation Details

Architecture Details of Development Phase :

Layer Name	Input Size	Output Size	Kernel	Stride
Conv1-1	20 x 80 x 40 x 1	18 x 80 x 36 x 16	3 x 1 x 5	1 x 1 x 1
Conv1-2	18 x 80 x 36 x 16	16 x 36 x 36 x 16	3 x 9 x 1	1 x 2 x 1
Pool1	16 x 36 x 36 x 16	16 x 36 x 18 x 16	1 x 1 x 2	1 x 1 x 2
Conv2-1	16 x 36 x 18 x 16	14 x 36 x 15 x 32	3 x 1 x 4	1 x 1 x 1
Conv2-2	14 x 36 x 15 x 32	12 x 15 x 15 x 32	3 x 8 x 1	1 x 2 x 1
Pool2	12 x 15 x 15 x 32	12 x 15 x 7 x 32	1 x 1 x 2	1 x 1 x 2
Conv3-1	12 x 15 x 7 x 32	10 x 15 x 5 x 64	3 x 1 x 3	1 x 1 x 1
Conv3-2	10 x 15 x 5 x 64	8 x 9 x 5 x 64	3 x 7 x 1	1 x 1 x 1
FC4	8 x 9 x 5 x 64	64	-	-
FC5	64	200	-	-

Table 1: Architecture Details

PYTORCH

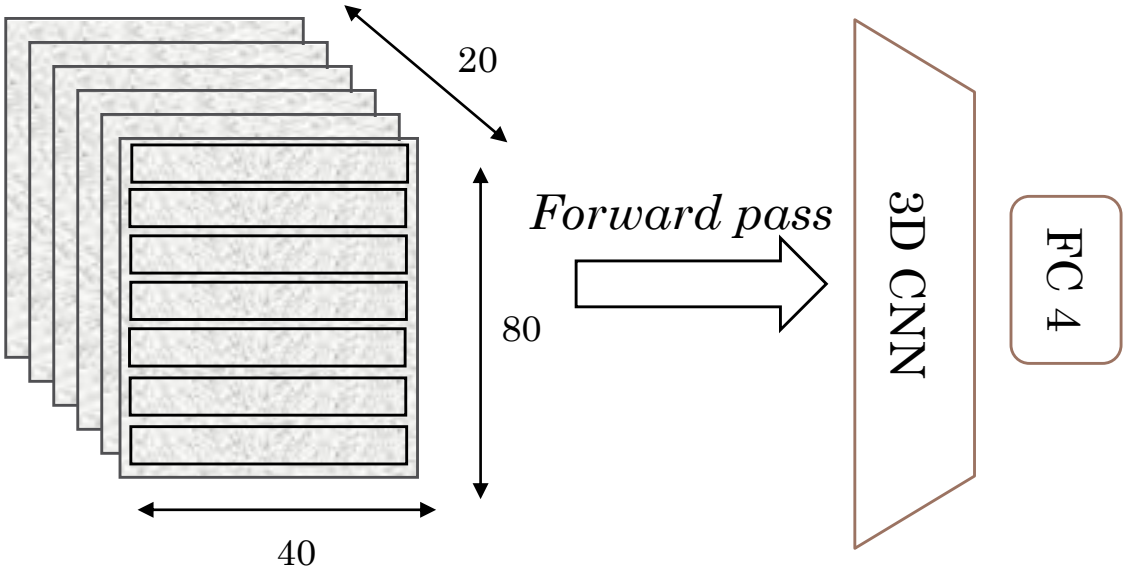
Implementation Details

Architecture Details of Development Phase :

- Activation Function – PReLU
- Loss Function – Cross Entropy, Classify 200 Speakers
- Pooling – Careful Temporal Pooling
- Dropout – Huge Training Time, Settled for Weight Decay L_2
- Batch Norm – Important, Otherwise Training is Stuck, No learning
- Batch Size – As much as possible in the GPU, Batch size = 128

Implementation Details

Enrollment Phase :



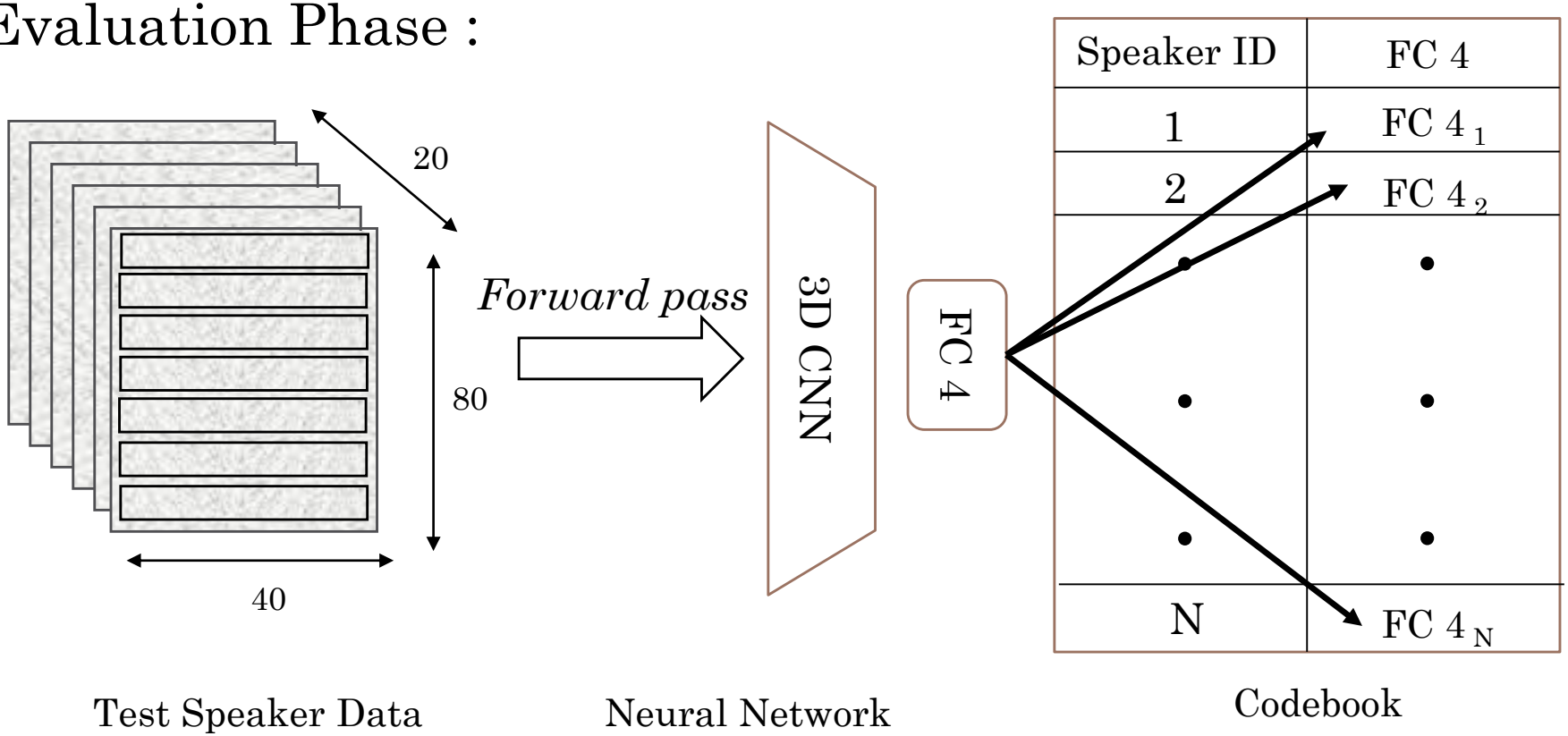
Speaker ID	FC 4
1	FC 4 $_1$
2	FC 4 $_2$
•	•
•	•
•	•
N	FC 4 $_N$

Speaker Data | Neural Network | Codebook

Important : *Set network training flag to false !!!*

Implementation Details

Evaluation Phase :



- *Minimum distance of test feature to existing enrolled features*
- *Distance threshold needed to avoid unenrolled speakers getting verified*

Implementation Details

Data Set Details :

VoxCeleb : –

- 100,000 utterances for 1,251 celebrities.
- Size of this dataset is 160 GB.
- 3 days to download.
- Parallel on four machines.

For Training Development stage :-

- Used 200 speakers data.
- Each speaker had atleast 80 examples.
- Validation Set : Randomly Sampled 10% Subset

For Enrollment stage :-

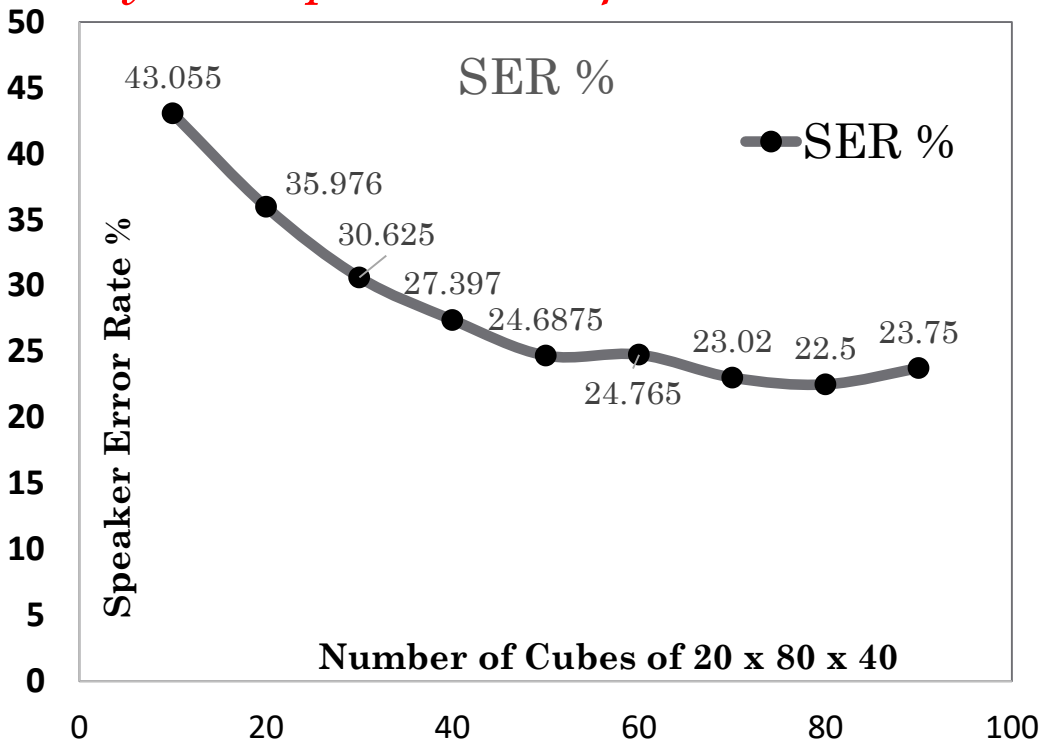
- *Codebook Formation*
- *Case 1* : Using speakers from training set (32x80)
- *Case 2* : From test set (32x80)
- On an average 16 mins of speech required for enrollment.

For Evaluation stage :-

- Speaker Identification
- Speaker Verification
  - Positive and negative data.

Result for speaker Identification task

How Many Examples needed for enrollment ?

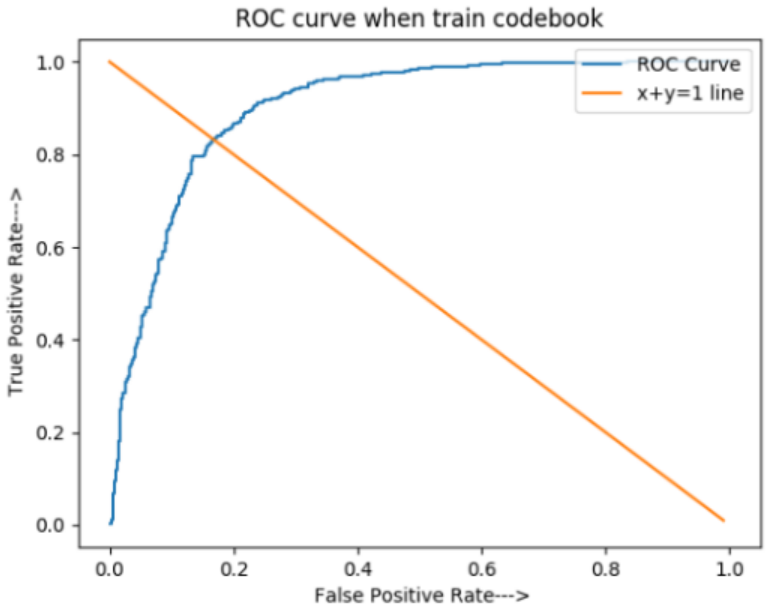


Why So many example during enrollment ?

Data	Accuracy
Train	92.491 %
Validation	68.213 %

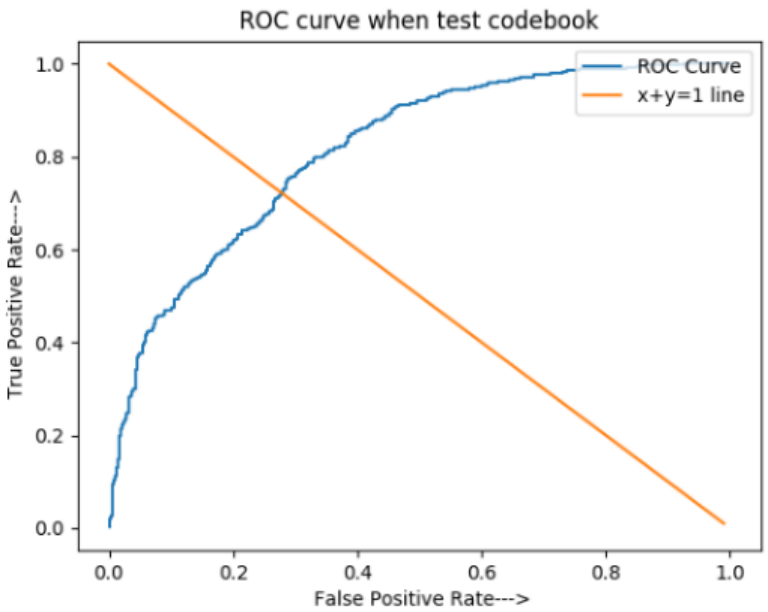
Development phase training results

Results for speaker verification task



Error	Percentage
EER	16.875 %
SER	6.09375 %

Error rate for users from training dataset



Error	Percentage
EER	27.8125 %
SER	22.5 %

Error rate for users only from test dataset

Thank You