Replay Attack and Anti-Spoofing using F-ratio probing tool

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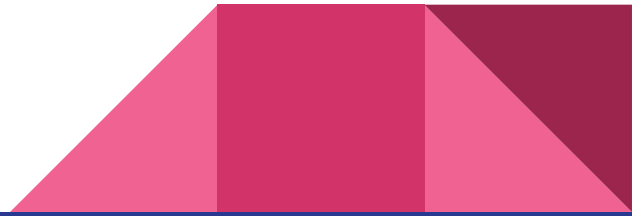
Overview of Stage - I

- used the F-ratio metric as a probing tool to analyze the impact of various speech factors to replay detection.
- To discover which frequency bands are most discriminative for detecting replayed speech.
- Factors like Speaker, Speech Phrase, Recording Environment, Recording Device, Playback Device.
- Check generalizability between training data and development data

Algorithm

- Read wav file
- Windowing and FFT
- Applying Mel filter bank
- Mean of frames on each filter bank
- Compute F-ratio on variability factor



Mel Triangular Filters(FFT to mel)

$$H_m(k) = \begin{cases} 0 & k < f(m-1) \\ \dfrac{k - f(m-1)}{f(m) - f(m-1)} & f(m-1) \le k \le f(m) \\ \dfrac{f(m+1) - k}{f(m+1) - f(m)} & f(m) \le k \le f(m+1) \\ 0 & k > f(m+1) \end{cases}$$

Algorithm

$$F_i = \frac{(\mu_i^g - \mu_i^r)^2}{\frac{1}{N_g}\sum_{x_i \in C_g}(x_i - \mu_i^g)^2 + \frac{1}{N_r}\sum_{x_i \in C_r}(x_i - \mu_i^r)^2}$$

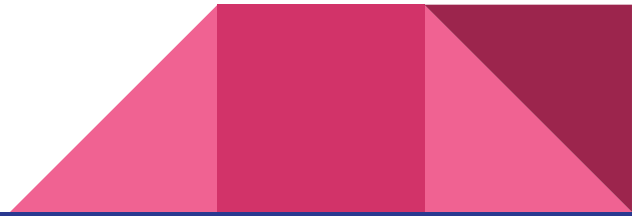
where x_i represents the value of the i-th Fbank of the speech frame x, and μ_i^g and μ_i^r are the means of x_i of all the frames of the genuine speech class and the replayed speech class, respectively. N_g and N_r are the number of frames of the two classes.

Values

Number of filter banks -> 40

Window Length -> 0.025s

Step between successive windows -> 0.01s



ASV Spoof 2017 Database

- Training Data

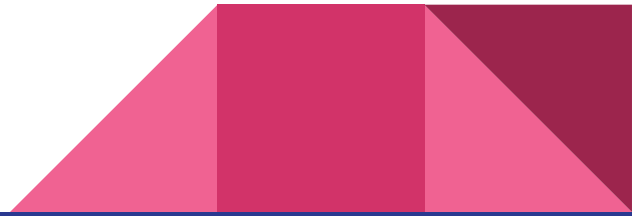
  Number of Genuine Utts. -> 1508

  Number of Spoofed Utts. -> 1508

- Development Data

  Number of Genuine Utts. -> 760

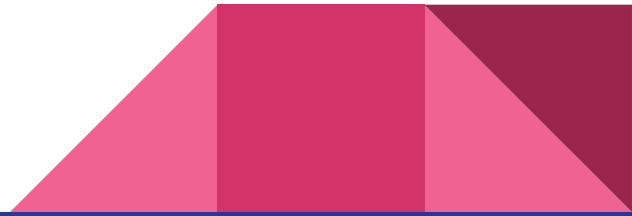
  Number of Spoofed Utts. -> 950



ASV Spoof 2017 Database

File contains:-

- Wave file
- Speech type (Genuine, Spoof)
- Speaker(Variability Factor)
- Phrase(Variability Factor)
- Environment(Variability Factor)
- Playback Device(Variability Factor)
- Recording Device(Variability Factor)



ASV Spoof 2017 Database

Training:-

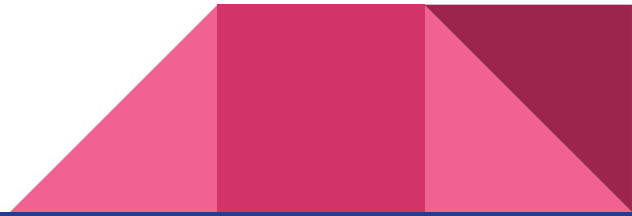
Number of Speakers -> 10

Number of Phrase -> 10

Number of Different Environment -> 2

Number of Playback Devices -> 3

Number of Recording Devices -> 1



ASV Spoof 2017 Database

Development:-

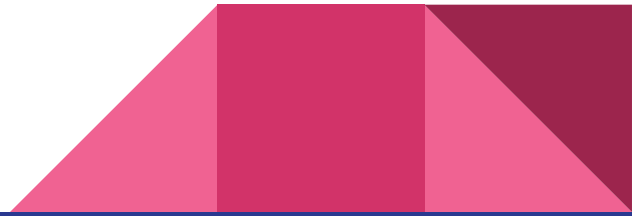
Number of Speakers -> 8

Number of Phrase -> 10

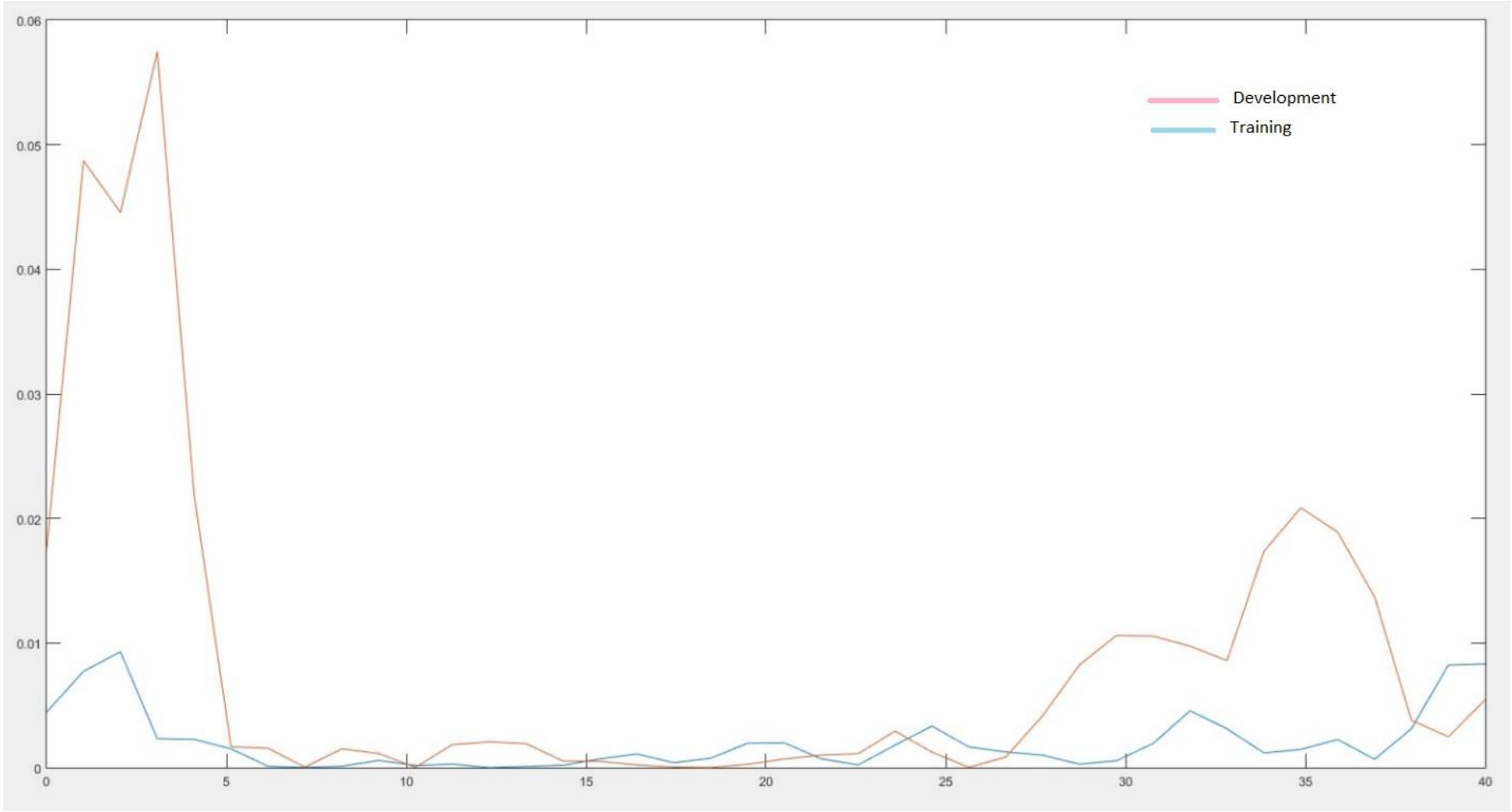
Number of Different Environment -> 6

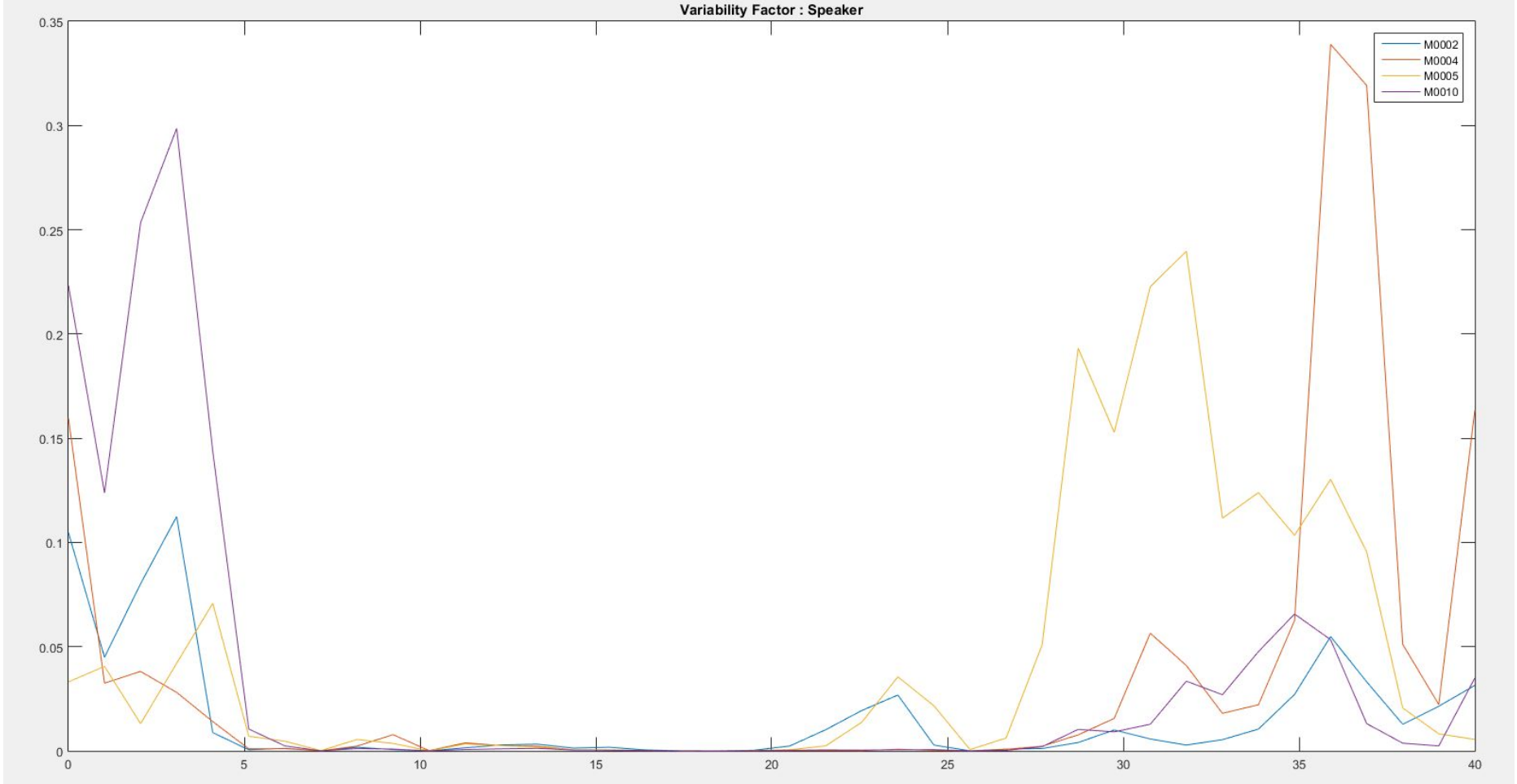
Number of Playback Devices -> 6

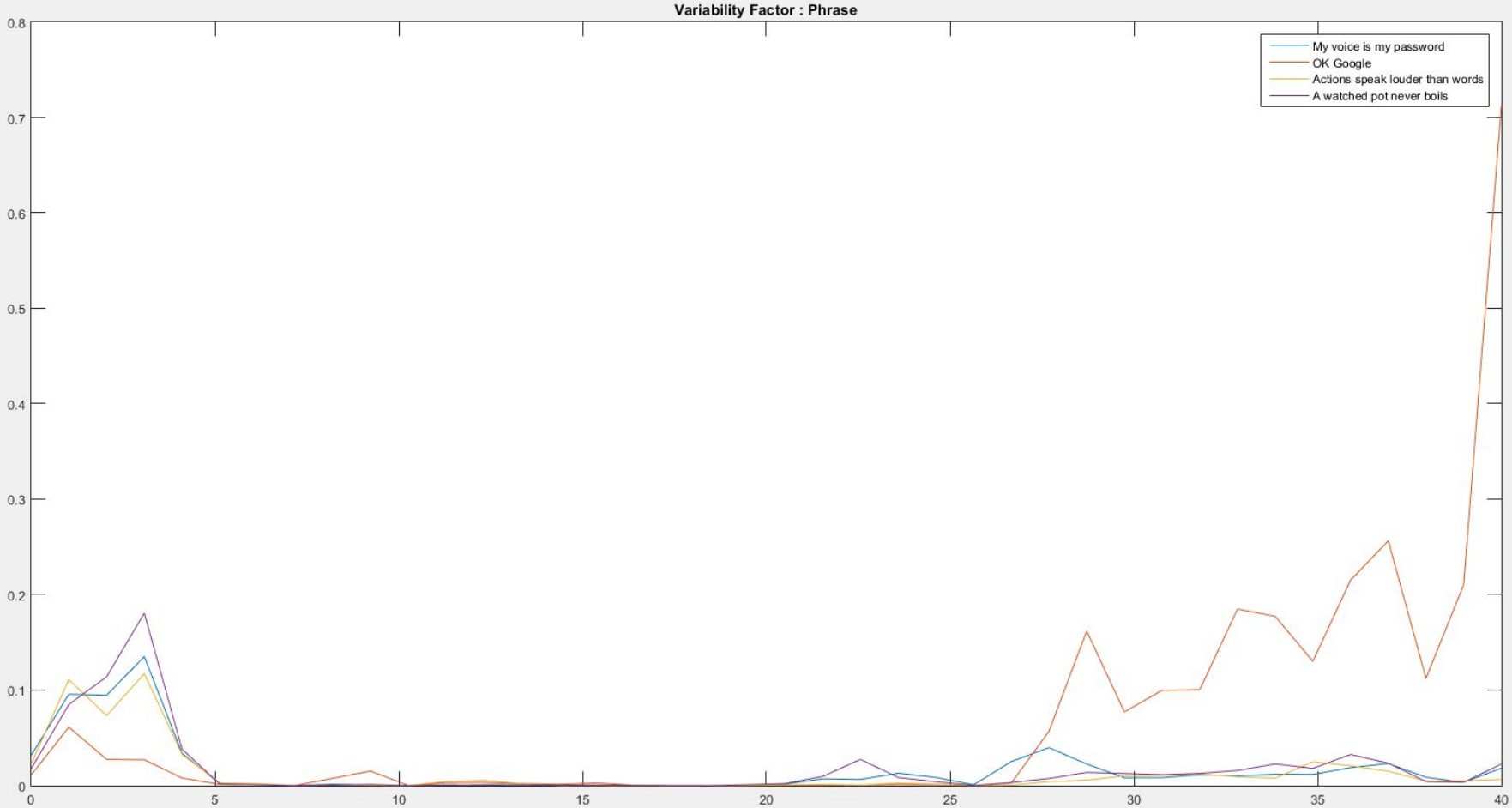
Number of Recording Devices -> 7

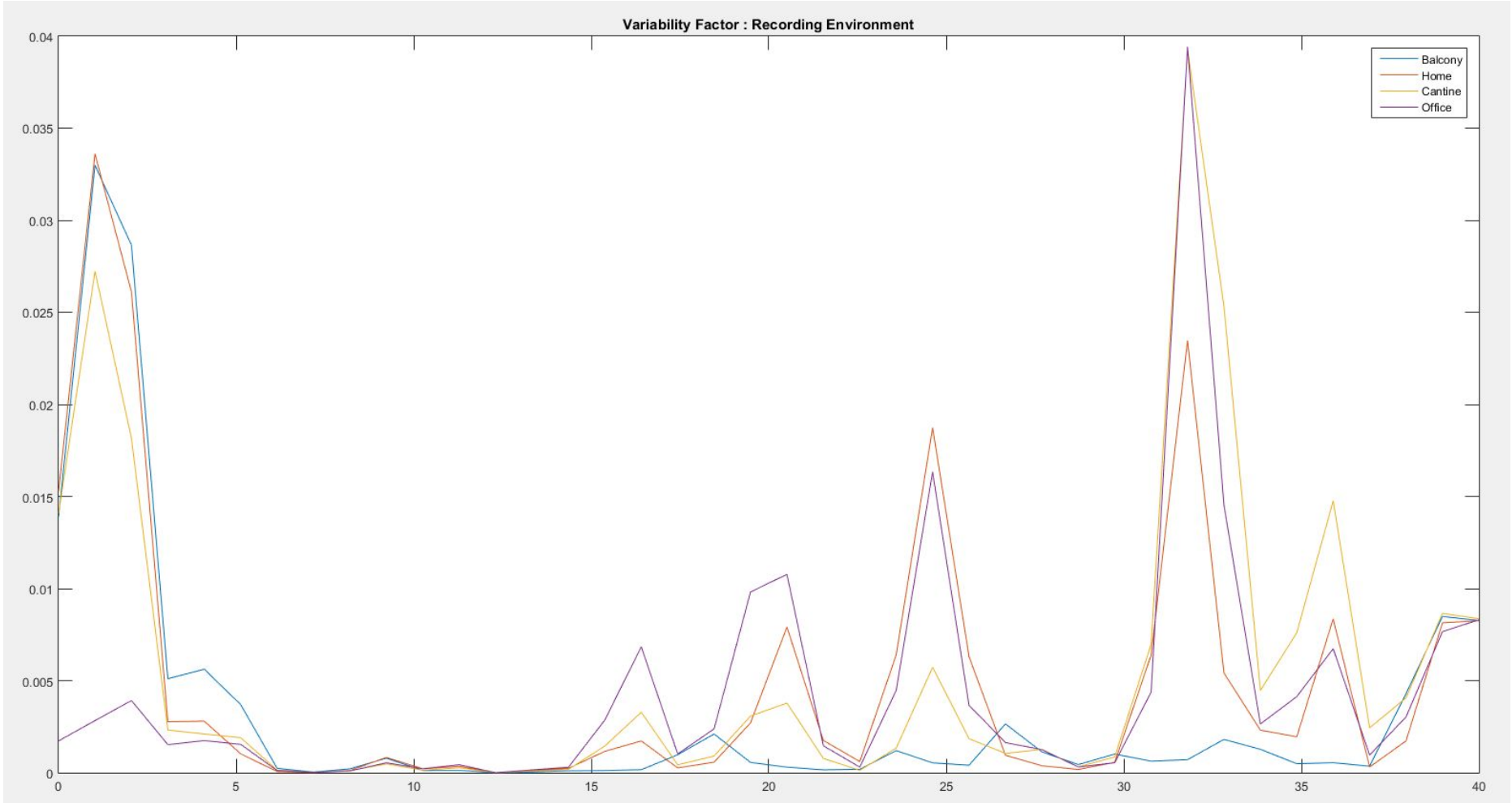


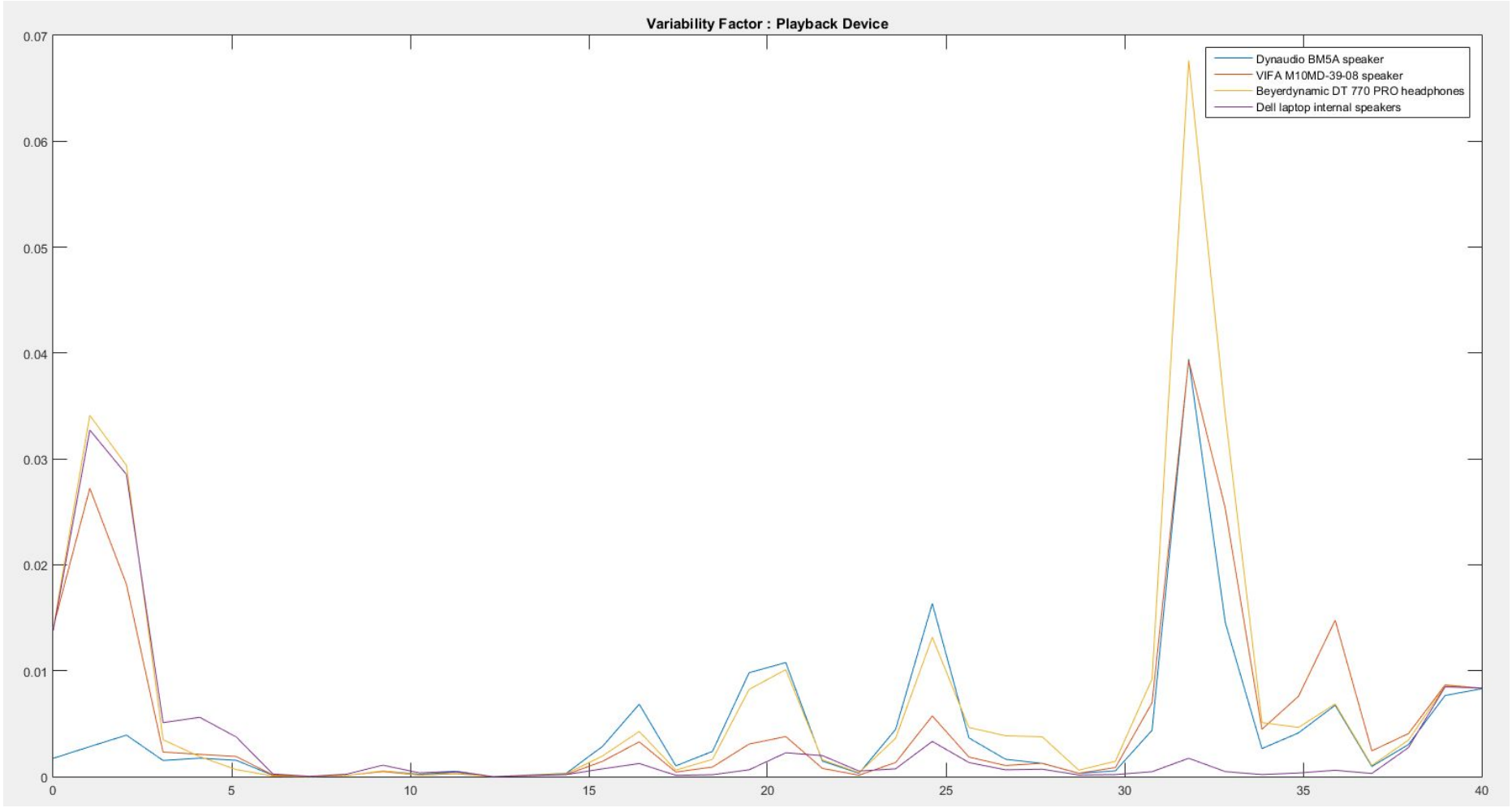
Results

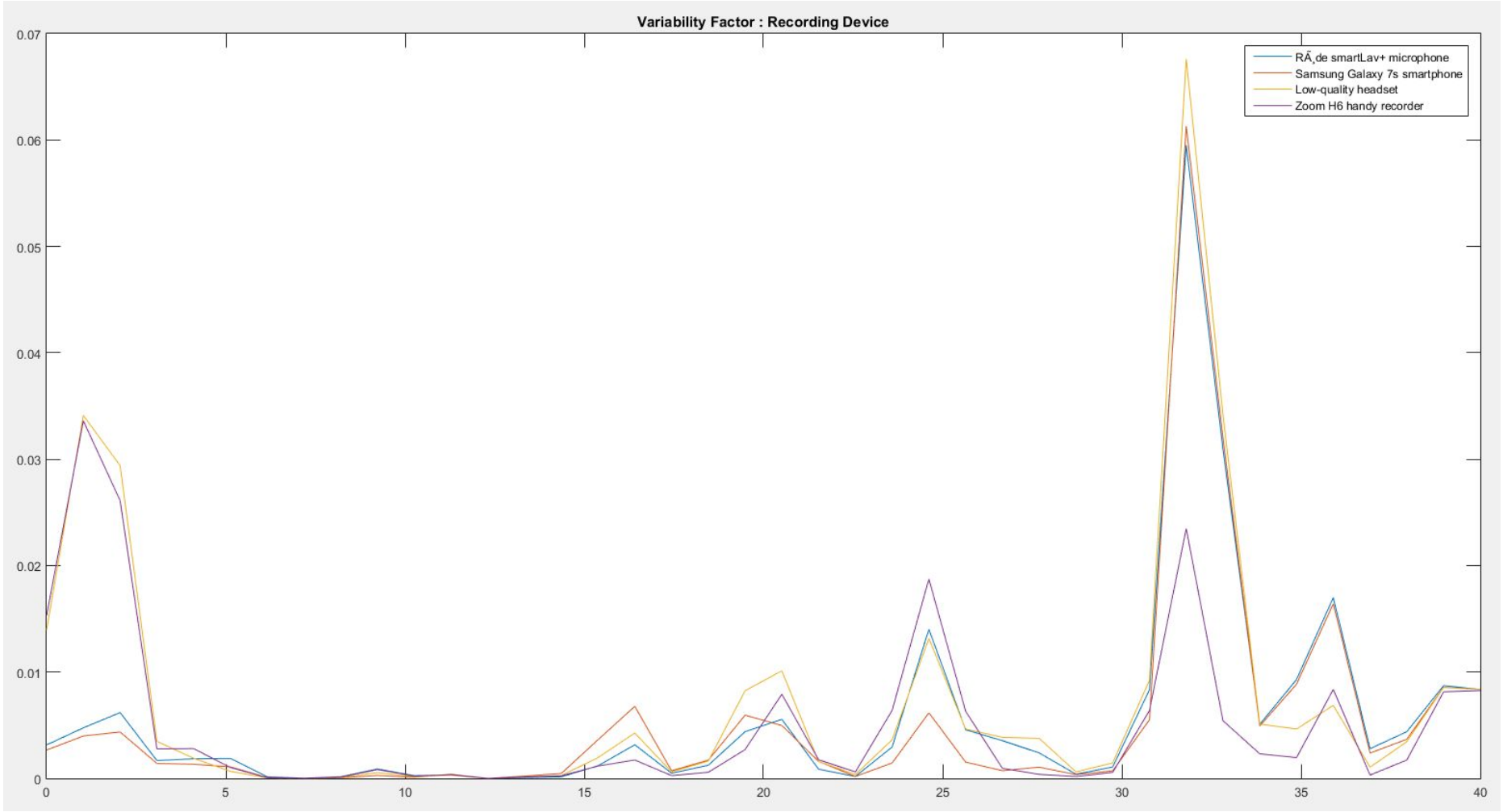

Development
Training
0.06
0.05
0.04
0.03
0.02
0.01
0
0
5
10
15
20
25
30
35
40


Variability Factor : Speaker
M0002
M0004
M0005
M0010
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30
35
40

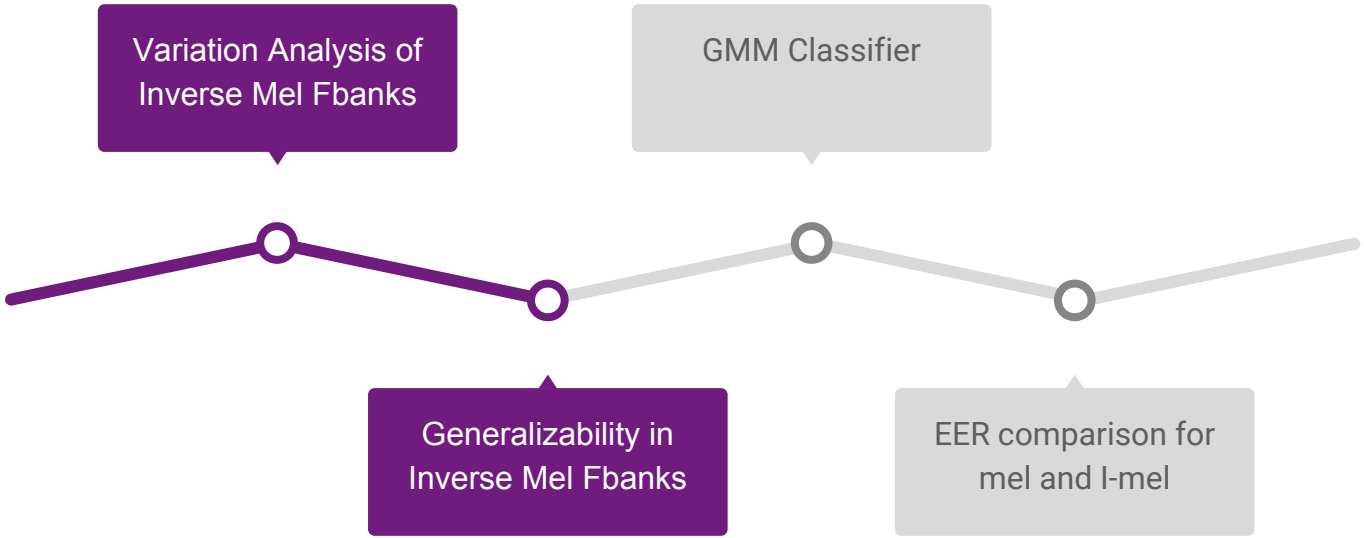

Variability Factor : Phrase
My voice is my password
OK Google
Actions speak louder than words
A watched pot never boils
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
5
10
15
20
25
30
35
40


Variability Factor : Recording Environment
Balcony
Home
Cantine
Office
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
5
10
15
20
25
30
35
40


Variability Factor : Playback Device
Dynaudio BM5A speaker
VIFA M10MD-39-08 speaker
Beyerdynamic DT 770 PRO headphones
Dell laptop internal speakers
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
5
10
15
20
25
30
35
40

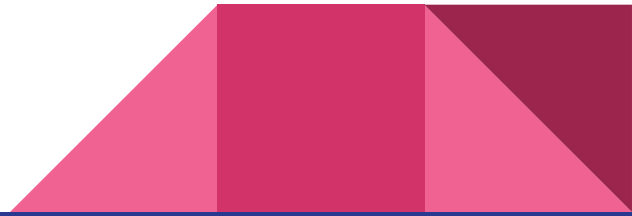

Variability Factor : Recording Device
RÃ¸de smartLav+ microphone
Samsung Galaxy 7s smartphone
Low-quality headset
Zoom H6 handy recorder
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
5
10
15
20
25
30
35
40

Timeline for Stage-III



Limitation of work

- Can not find discriminative information for replay detection for which frequency bands.
- More variation of F-ratio higher risk of overfitting.



Future Scope

- To discover which frequency bands are most discriminative for detecting replayed speech.
- the variation of the F-ratio patterns caused by a particular variability factor will reflect the impact of the factor and frequency warping to replay detection in generalizability.
- Factors like speaker identity, speech content, playback and recording device.

Thank You