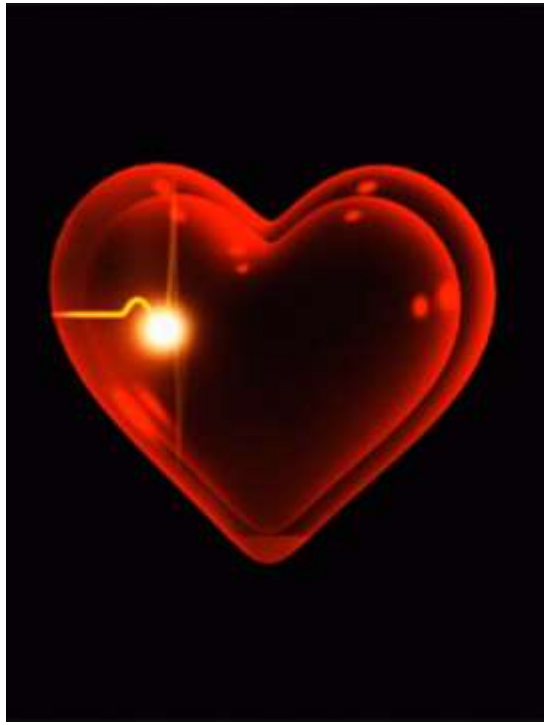
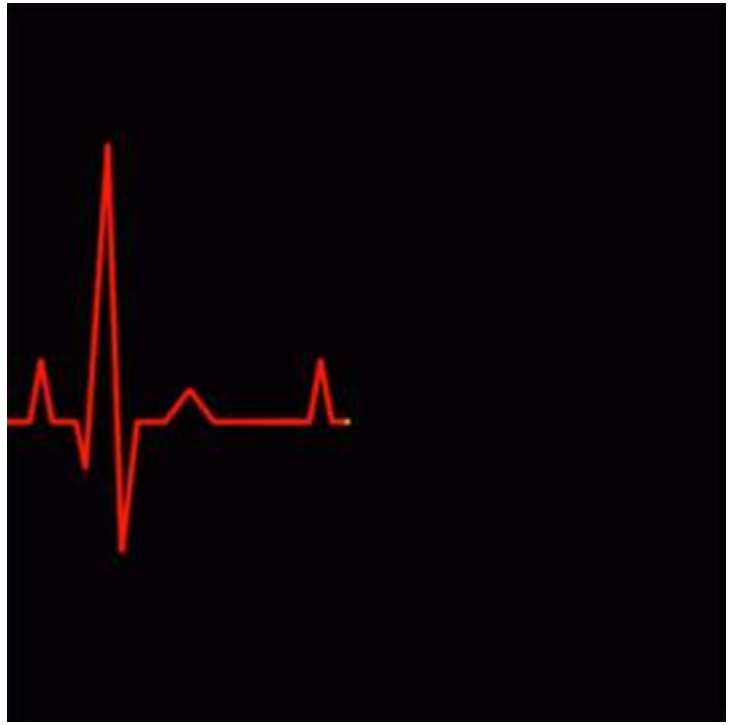
Signal tempo detection

Using convolution

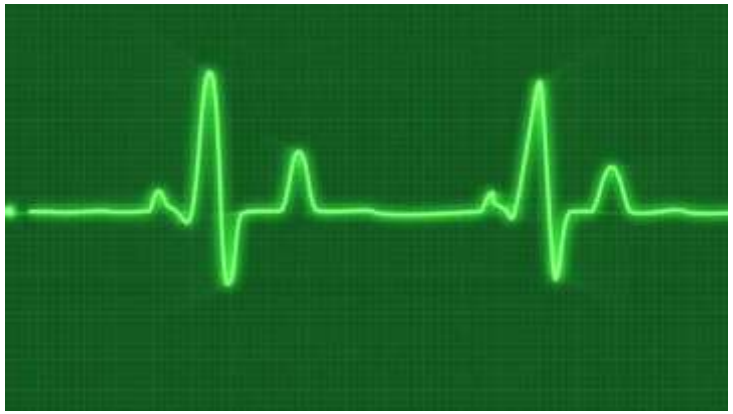
What is tempo?





Tempo Markings
(in beats per minute)

40-60	Largo	very slow
60-70	Adagio	slow
70-90	Andante	walking pace
90-110	Moderato	medium
110-140	Allegro	fast
140-160	Vivace	very fast
160+	Presto	reeeeealy fast



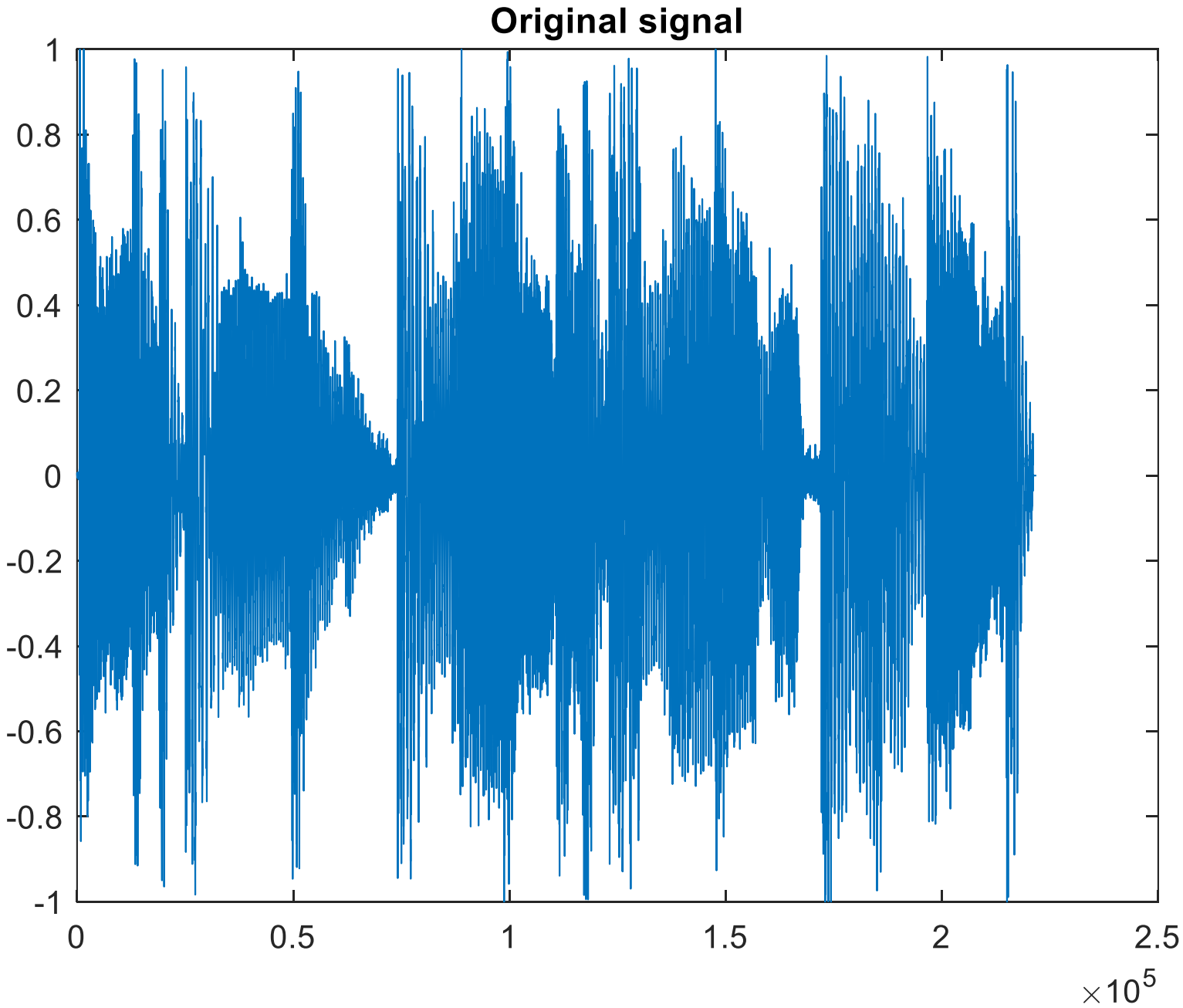
Methods for tempo finding

- Neural networks
- ODF, PeDF, post-processing paradigm
- Onset detection function, Periodicity detection function
- ODF: Modeling human hearing, detecting sharp energy changes, spectral flux observation
- PeDF: comb filtering, autocorrelation
- Variations on the paradigm
- “Beat this: A beat synchronization project” *Kileen Cheng, Bobak Nazer, Jyoti Uppuluri, Ryan Verret , Rice University*

“Beat this: A beat synchronization project”

1. Reading the signal
2. Bandpass filtering into 6 frequency bands
3. Full-wave rectification
4. Moving average filtering (Hanning window filtering)
5. Downsampling
6. Derivation
7. Half-wave rectification
8. Convolution
9. Processing the frequency band data

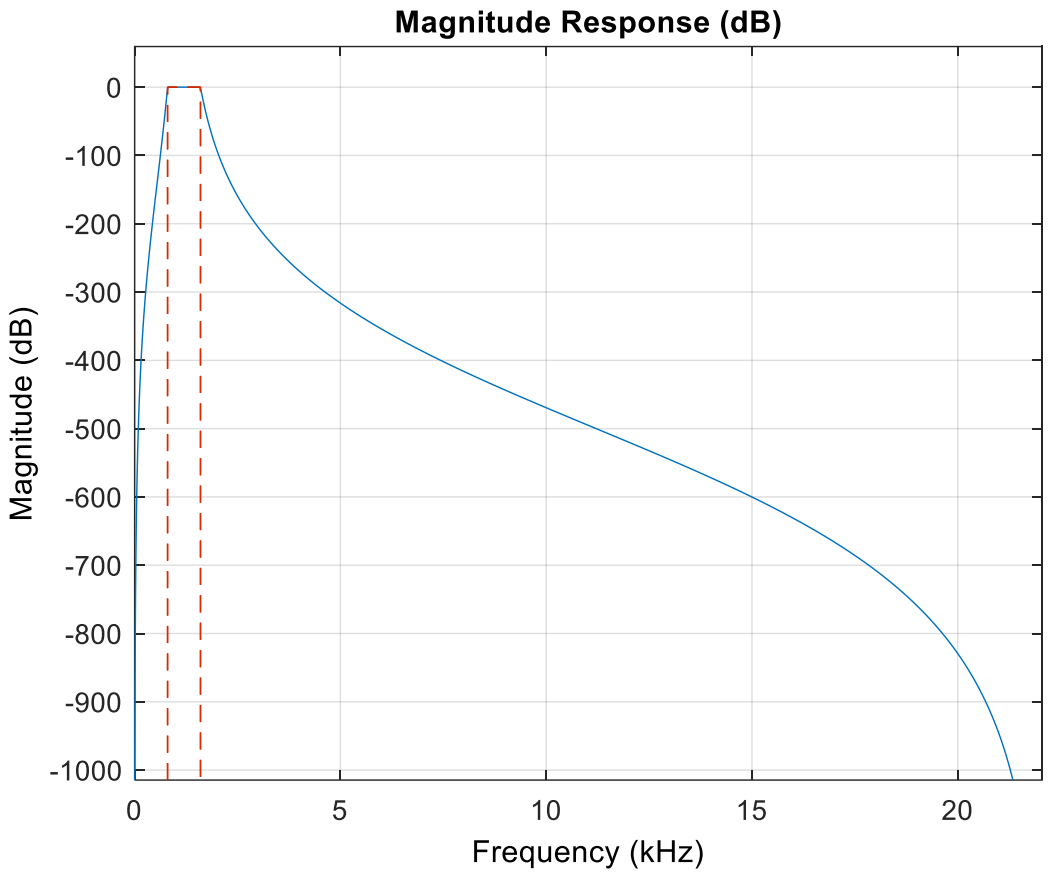
Raw signal data

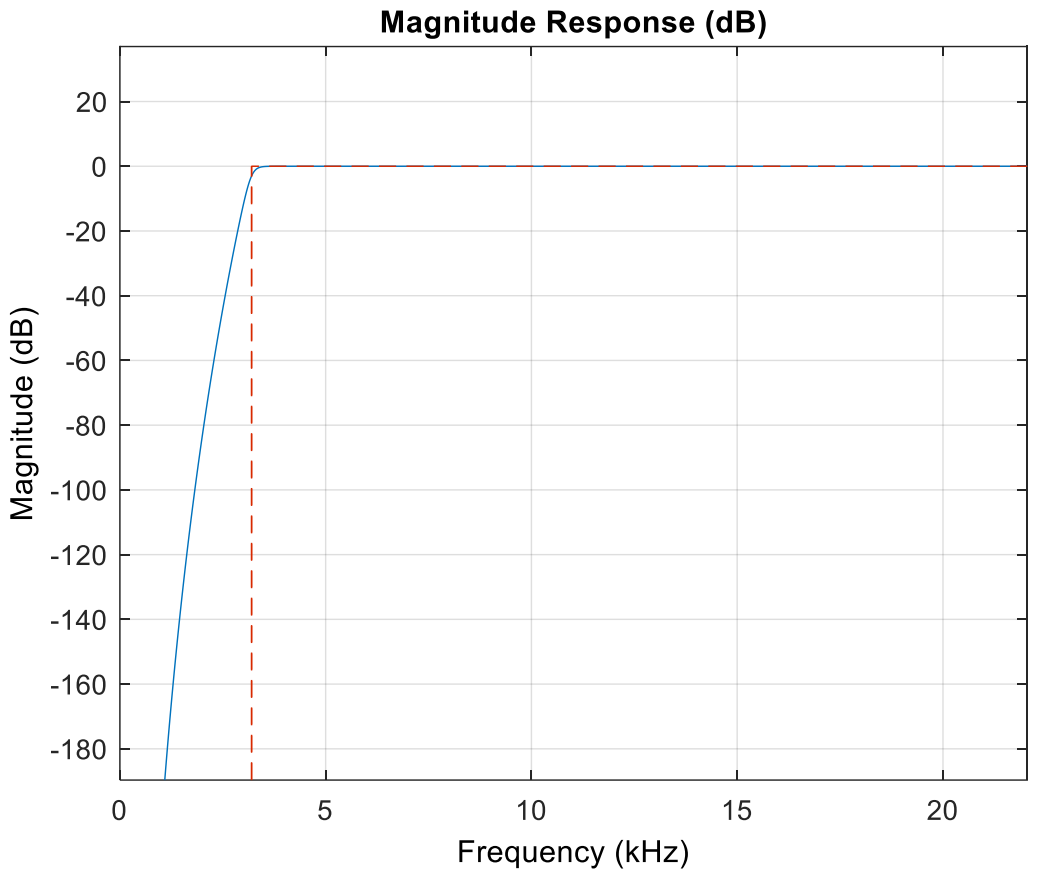


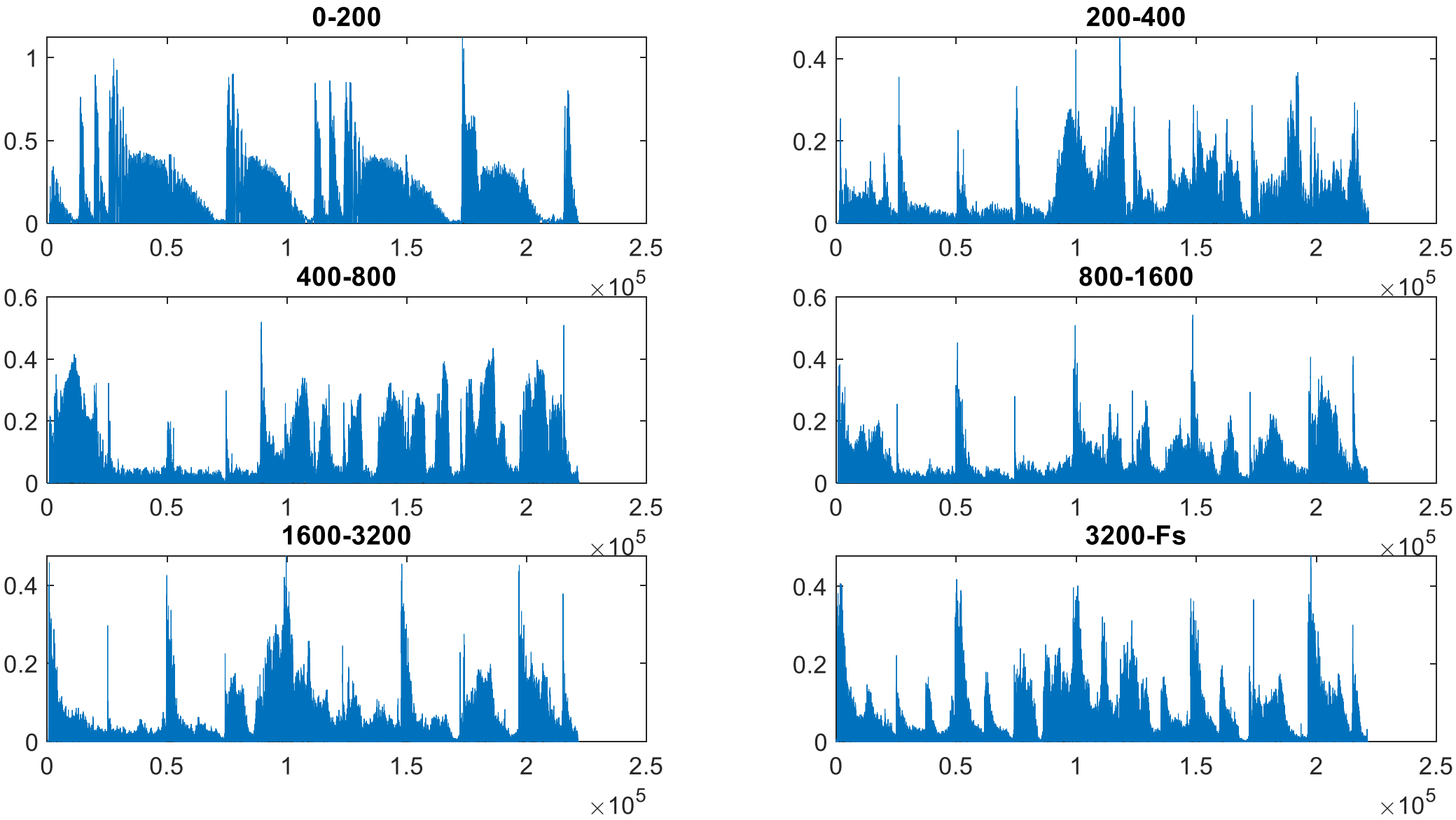
Bandpass filtering

	Type	Half power frequency/ies [Hz]
Filter 1	Low pass IIR	200
Filter 2	Band pass IIR	200, 400
Filter 3	Band pass IIR	400, 800
Filter 4	Band pass IIR	800, 1600
Filter 5	Band pass IIR	1600, 3200
Filter 6	High pass	3200

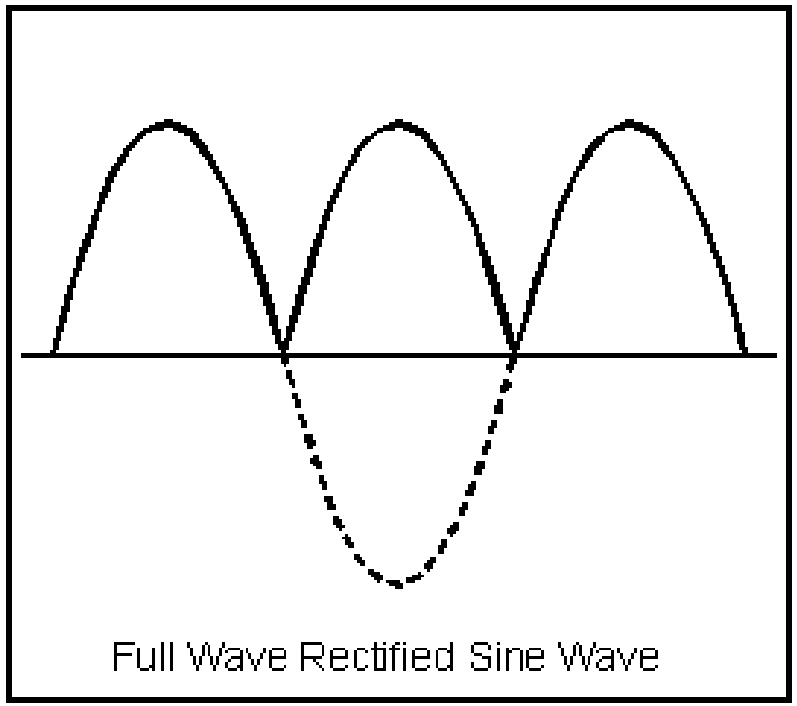
Bandpass and high-pass filter

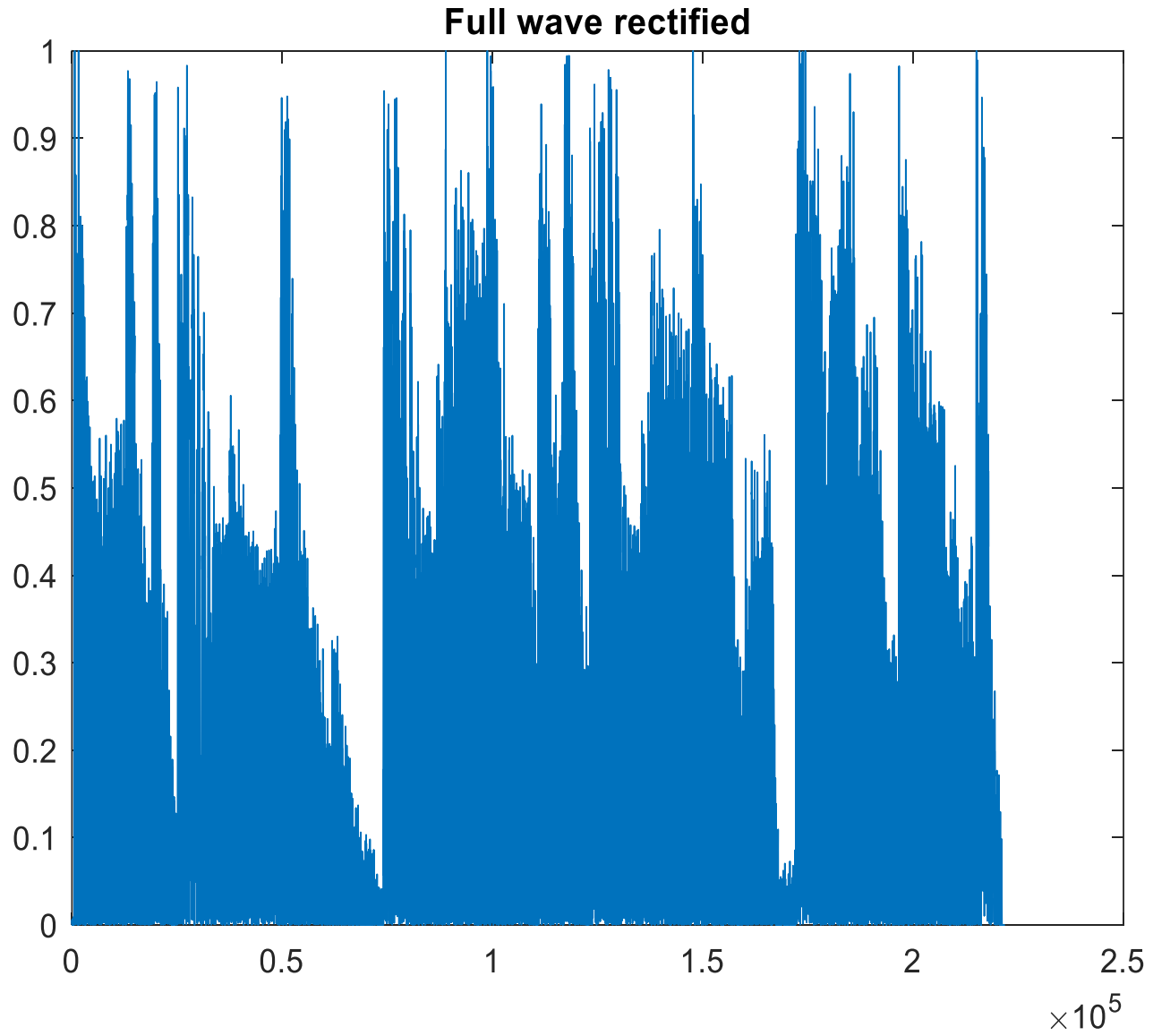


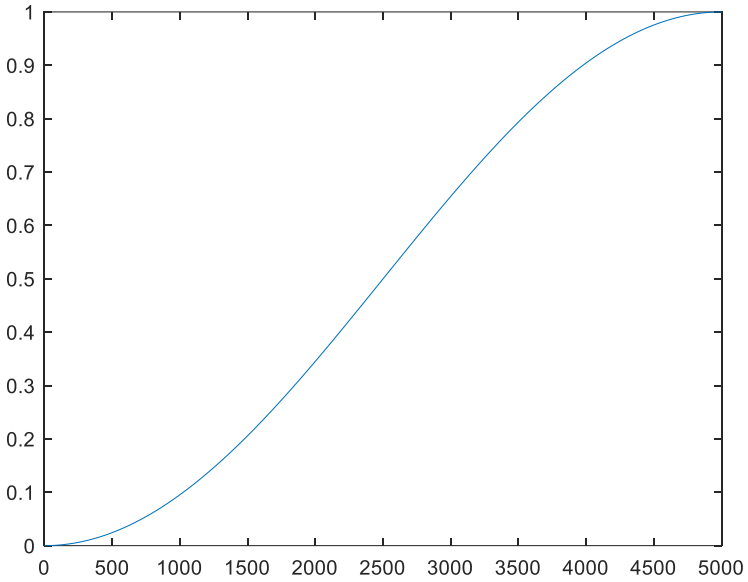


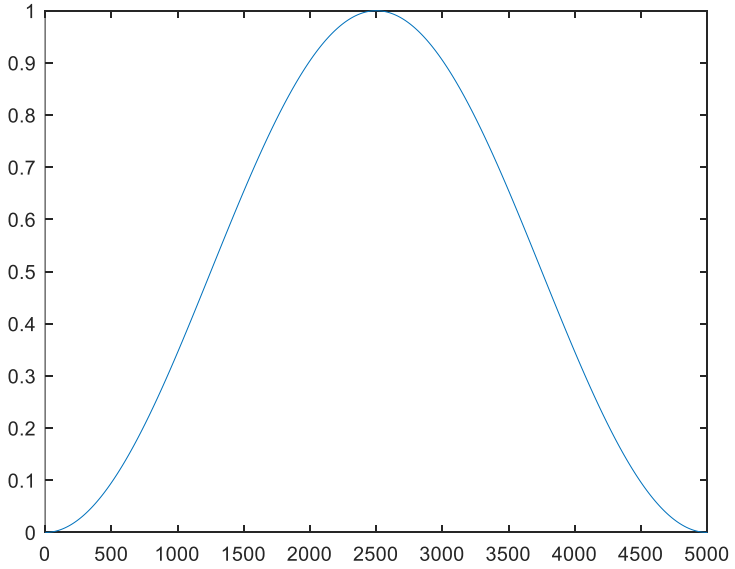

0-200
200-400
400-800
800-1600
1600-3200
3200-Fs
×10^5

Full wave rectification

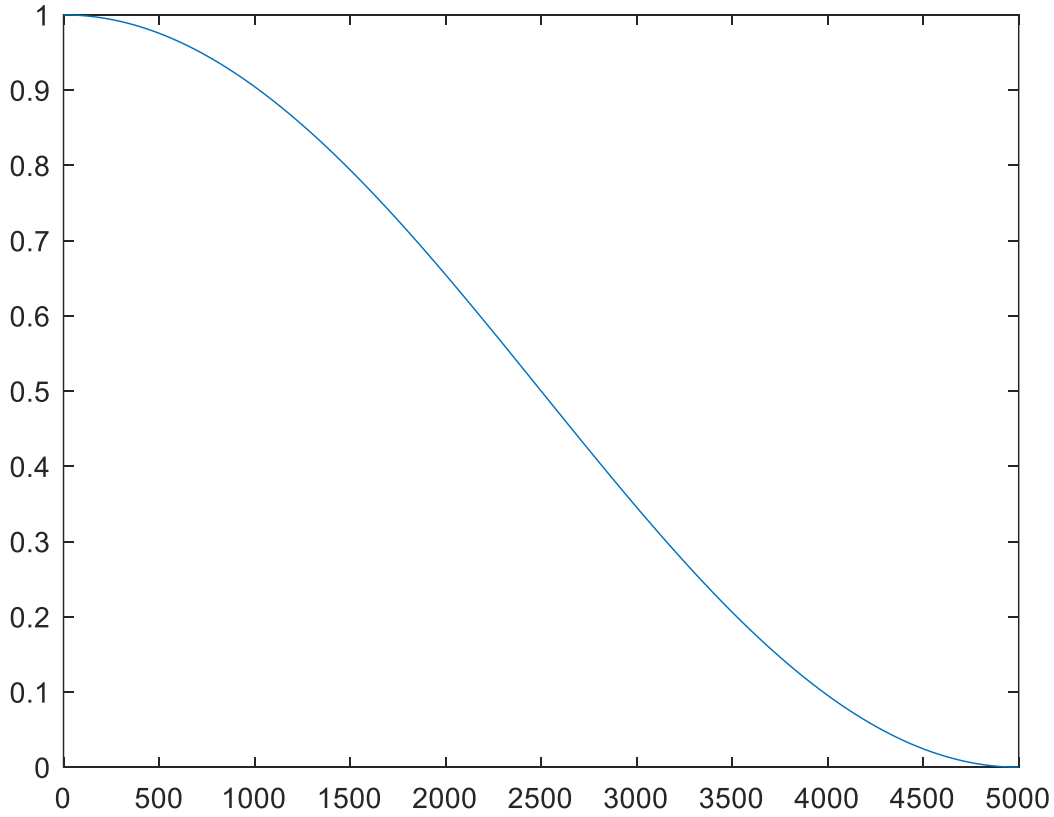


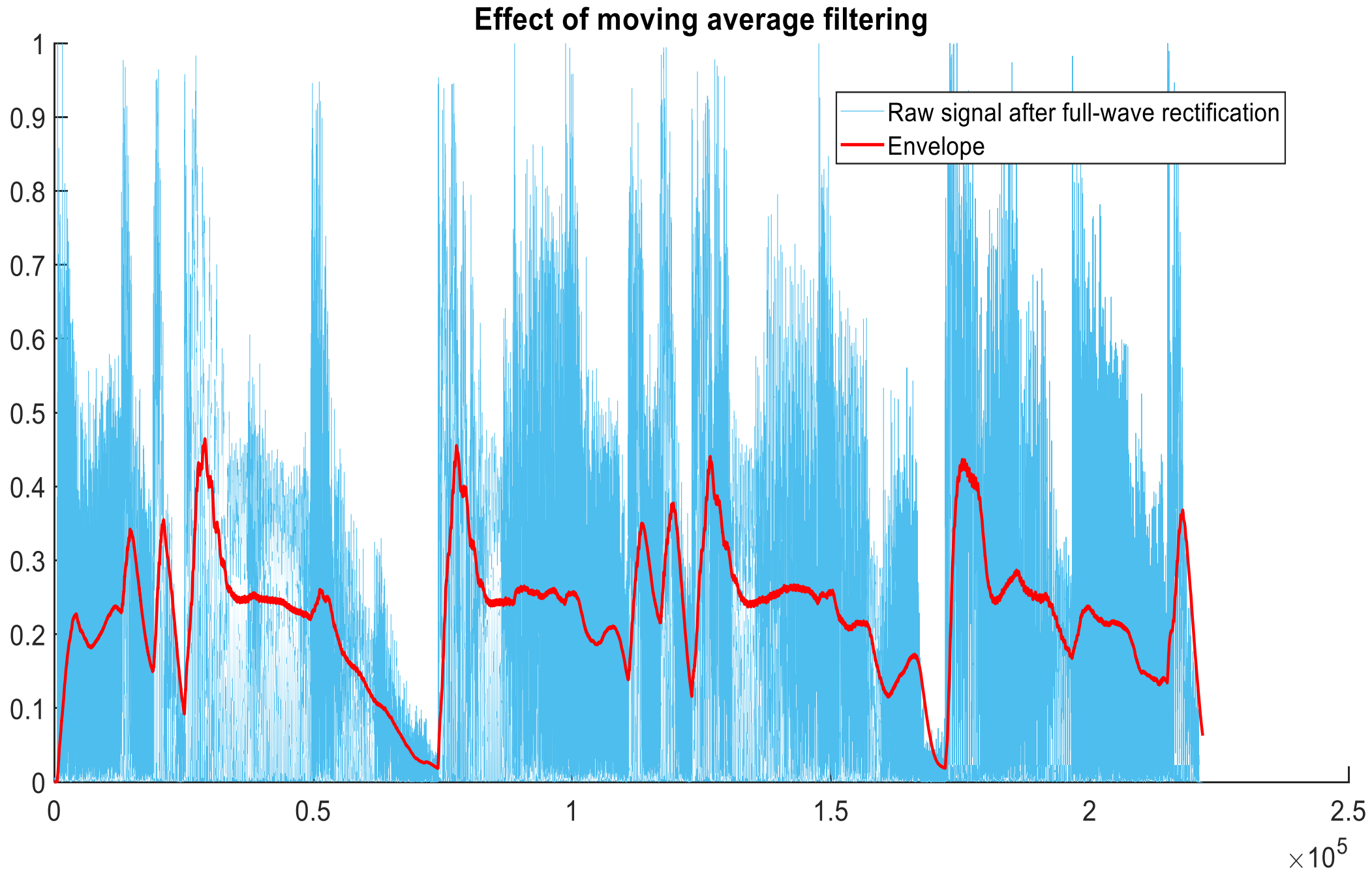


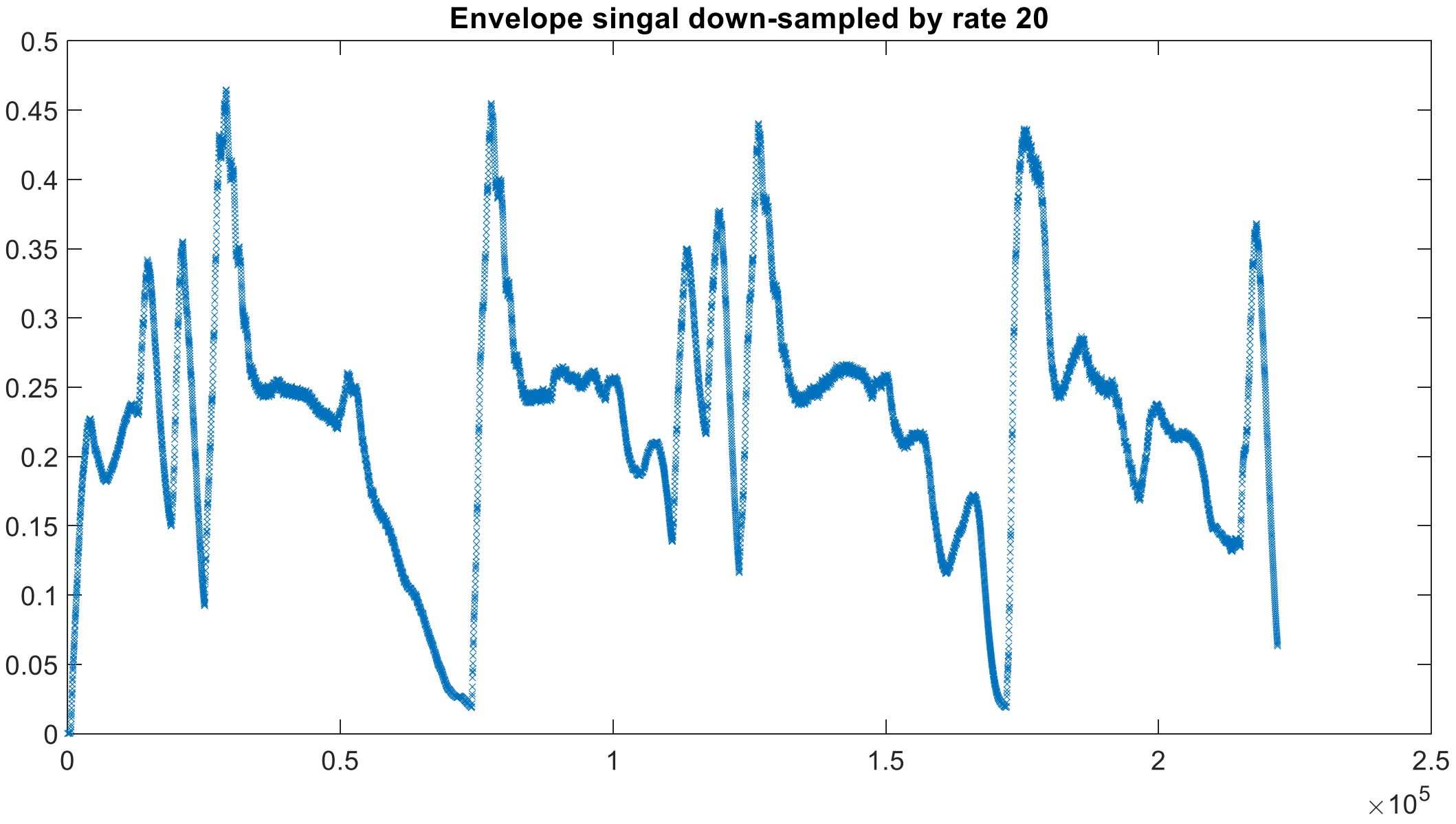


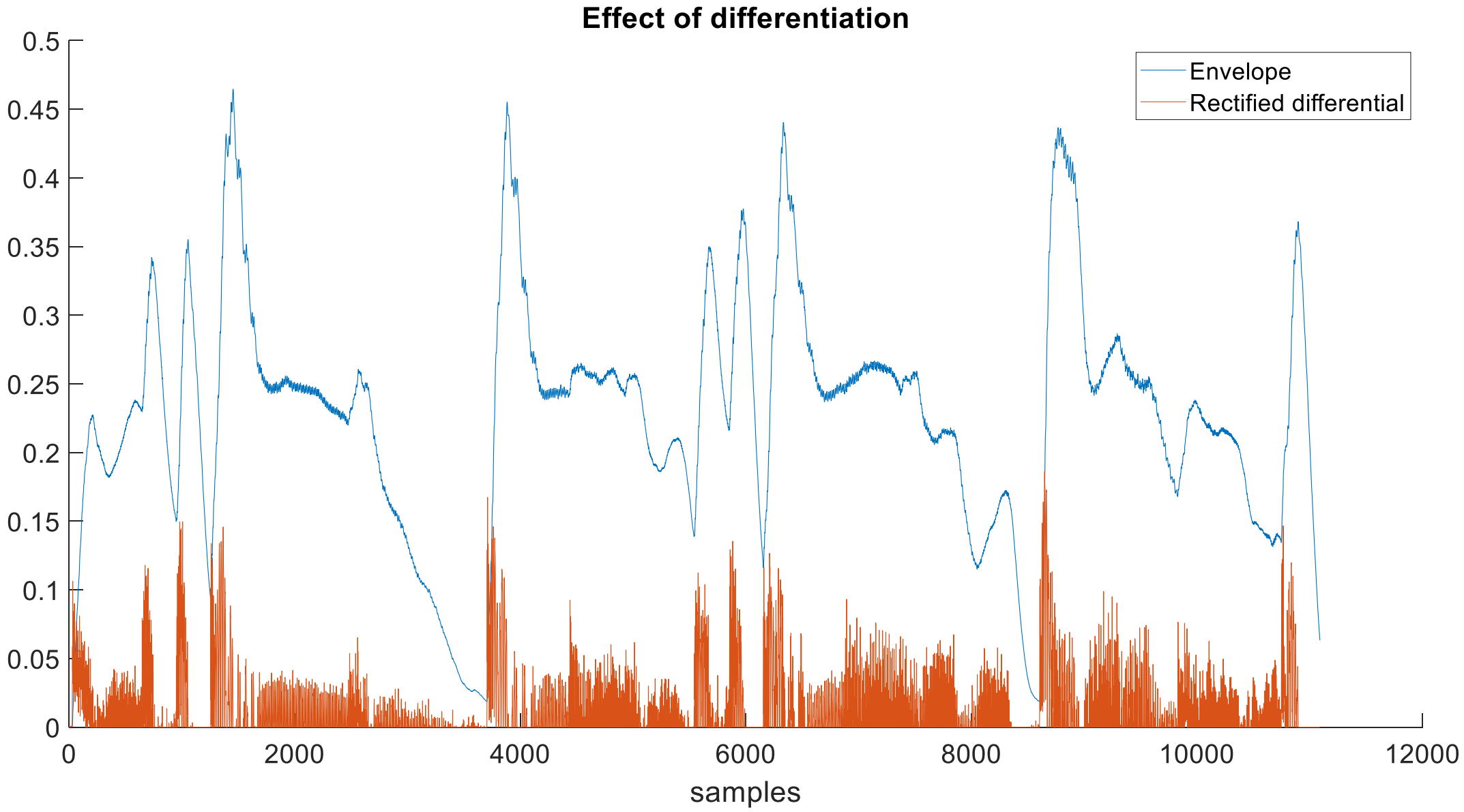


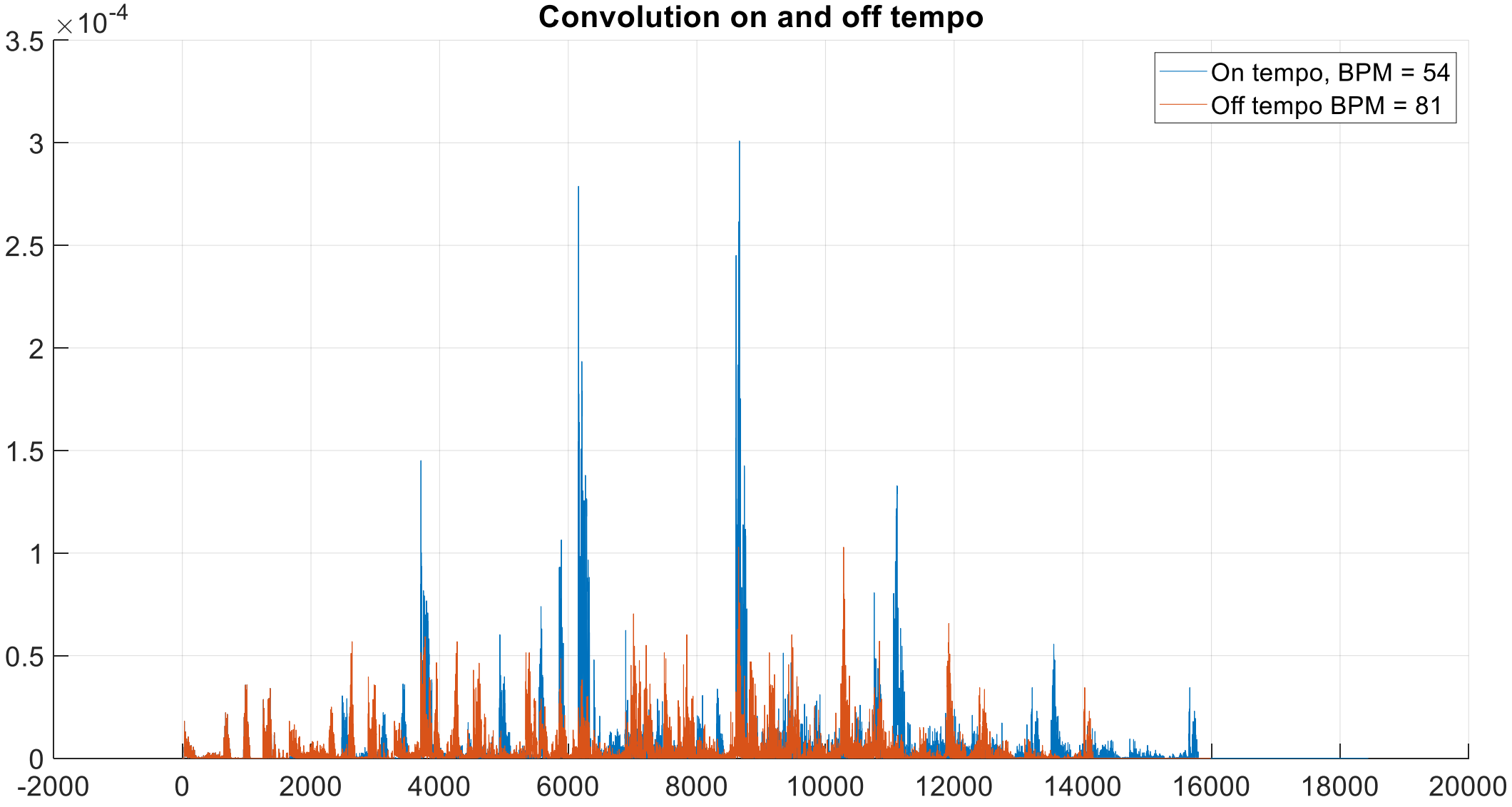
Moving average filter

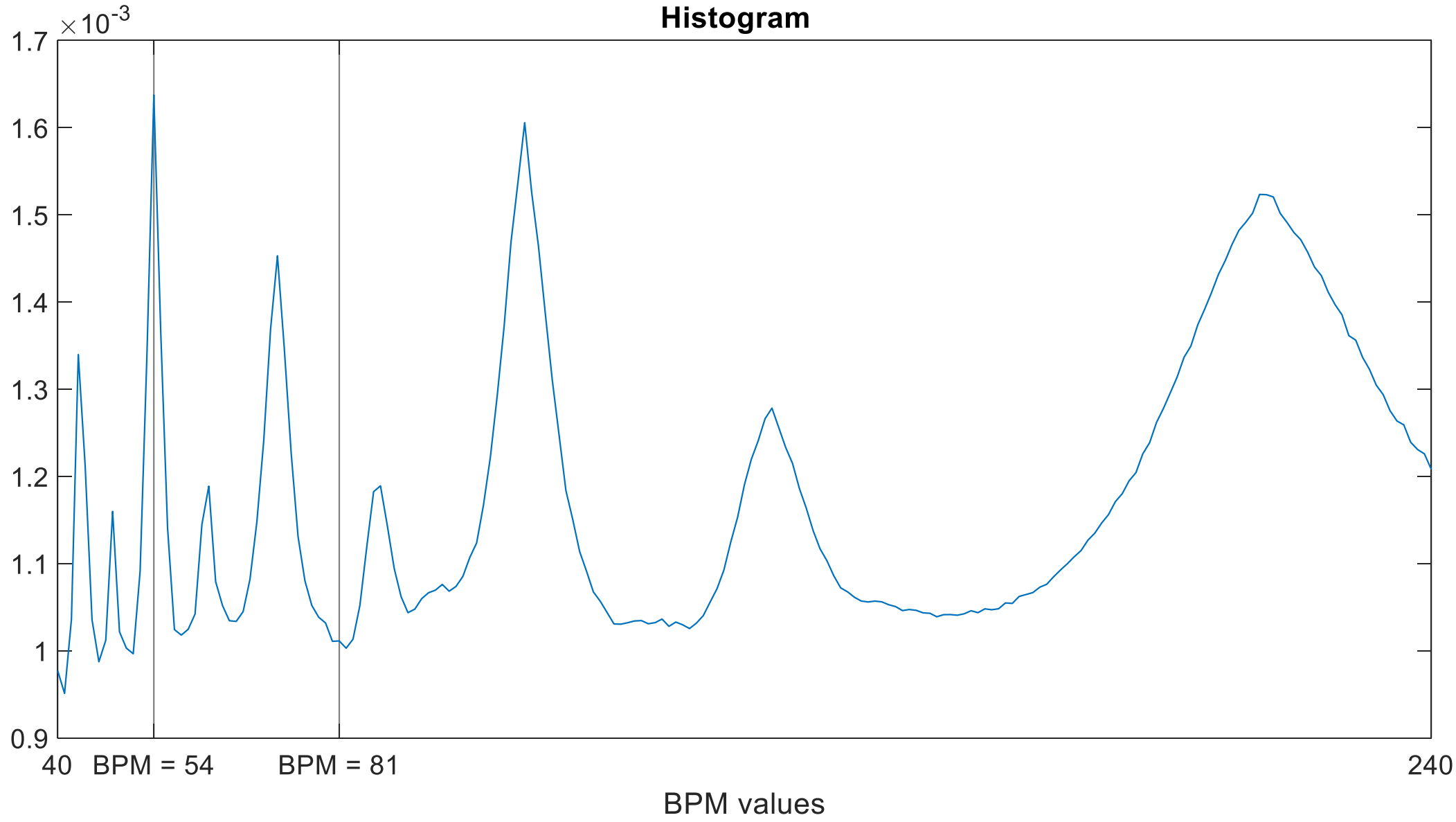



Effect of moving average filtering
Raw signal after full-wave rectification
Envelope
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
×10^5


Envelope singal down-sampled by rate 20
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.5
1
1.5
2
2.5
×10^5


Effect of differentiation
Envelope
Rectified differential
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
2000
4000
6000
8000
10000
12000
samples

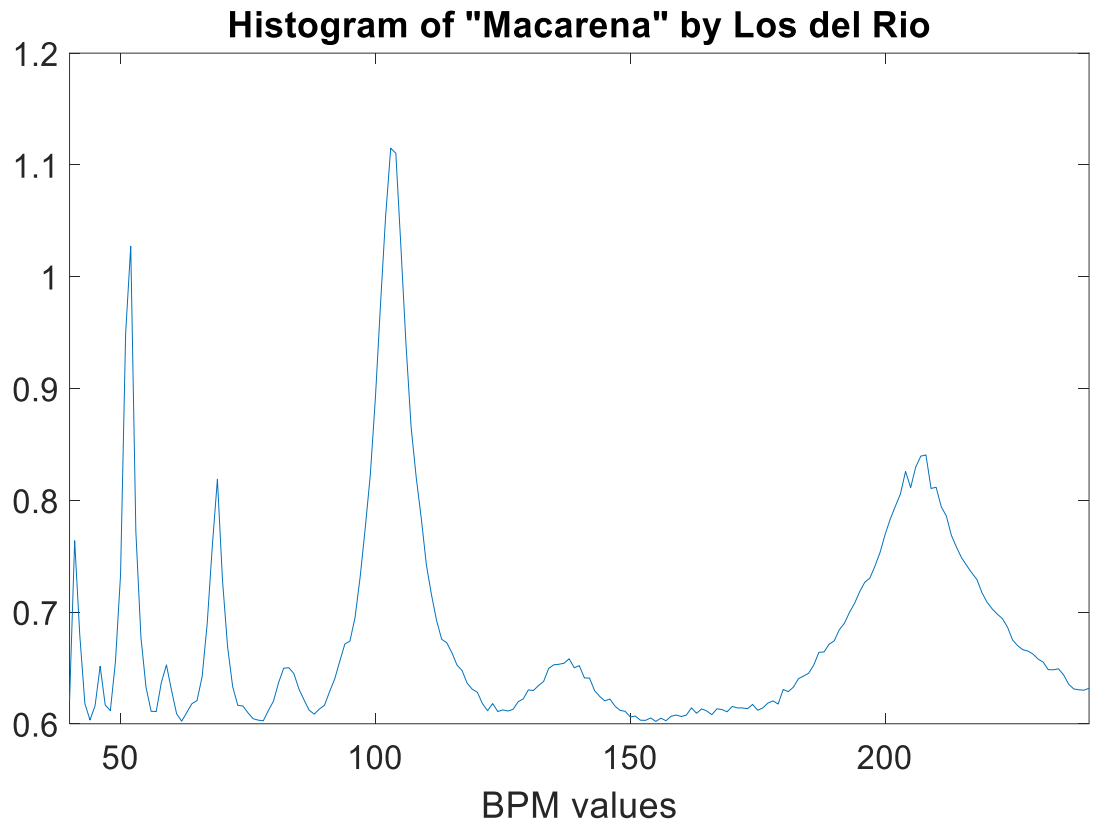

Convolution on and off tempo
×10^-4
3.5
3
2.5
2
1.5
1
0.5
0
-2000
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
On tempo, BPM = 54
Off tempo BPM = 81


Histogram
×10-3
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
40
BPM = 54
BPM = 81
240
BPM values

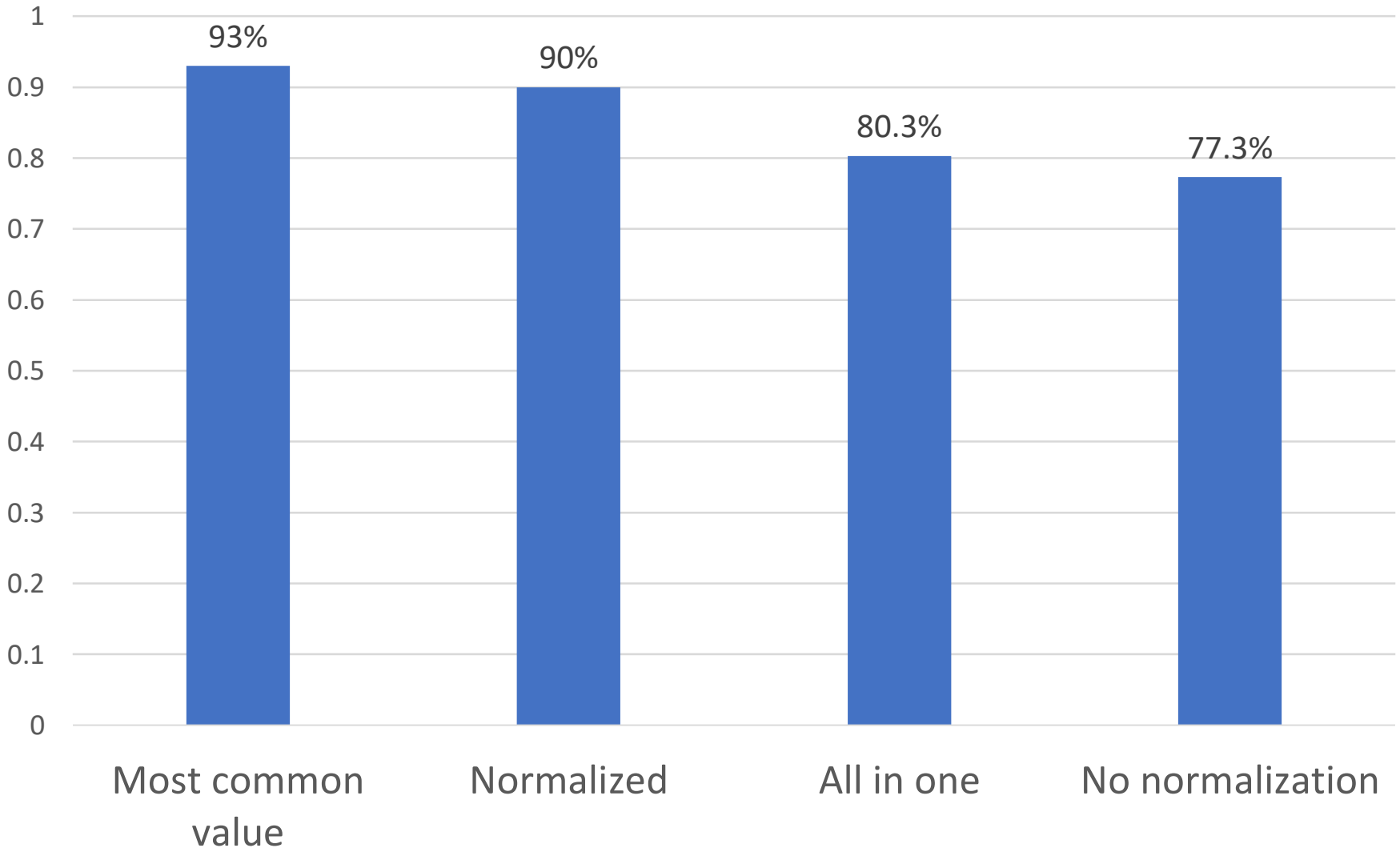
Three methods of frequency band data processing

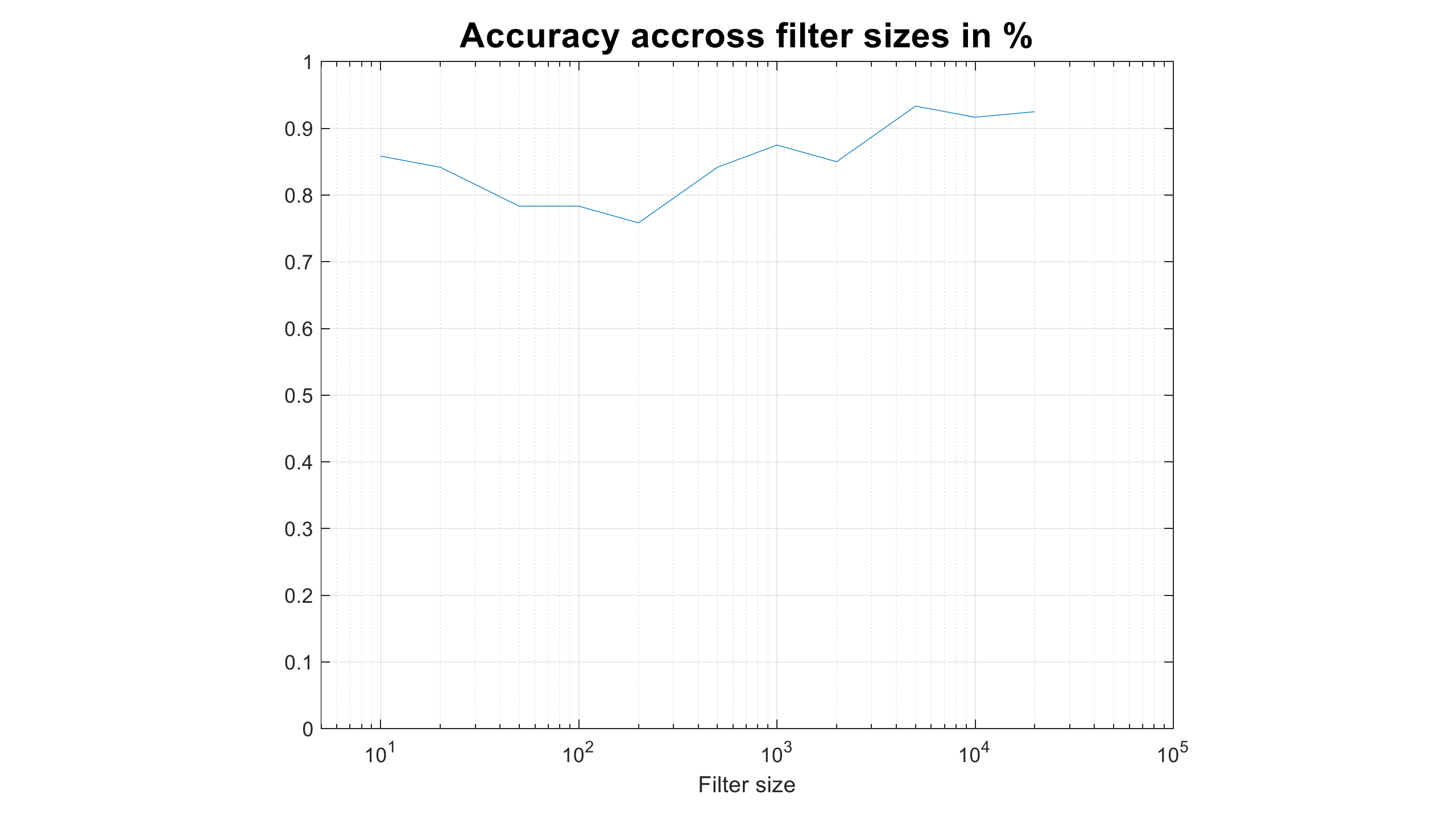
1. No normalization method
2. Normalized method
3. Most common value method

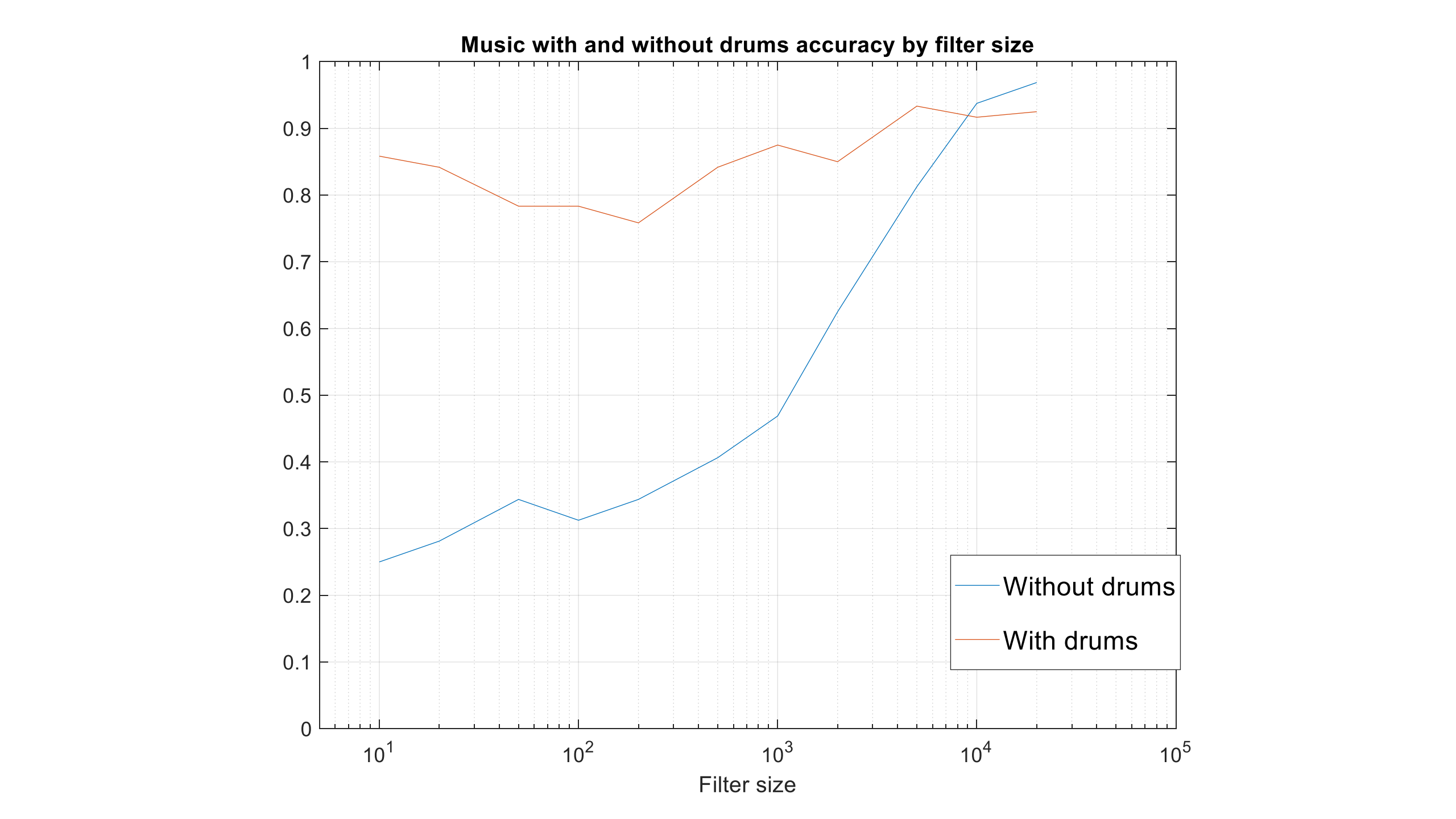
1. All in one method

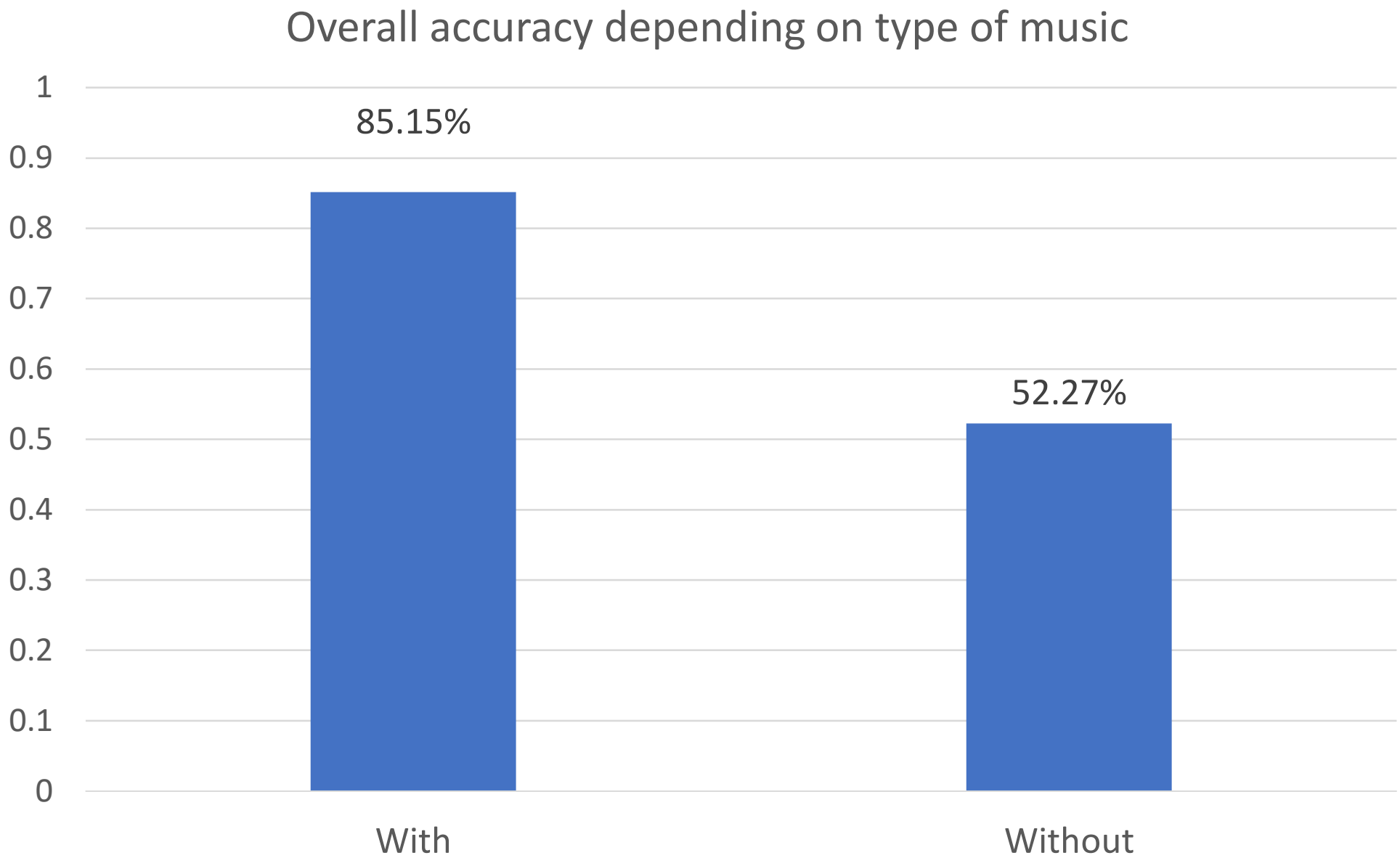


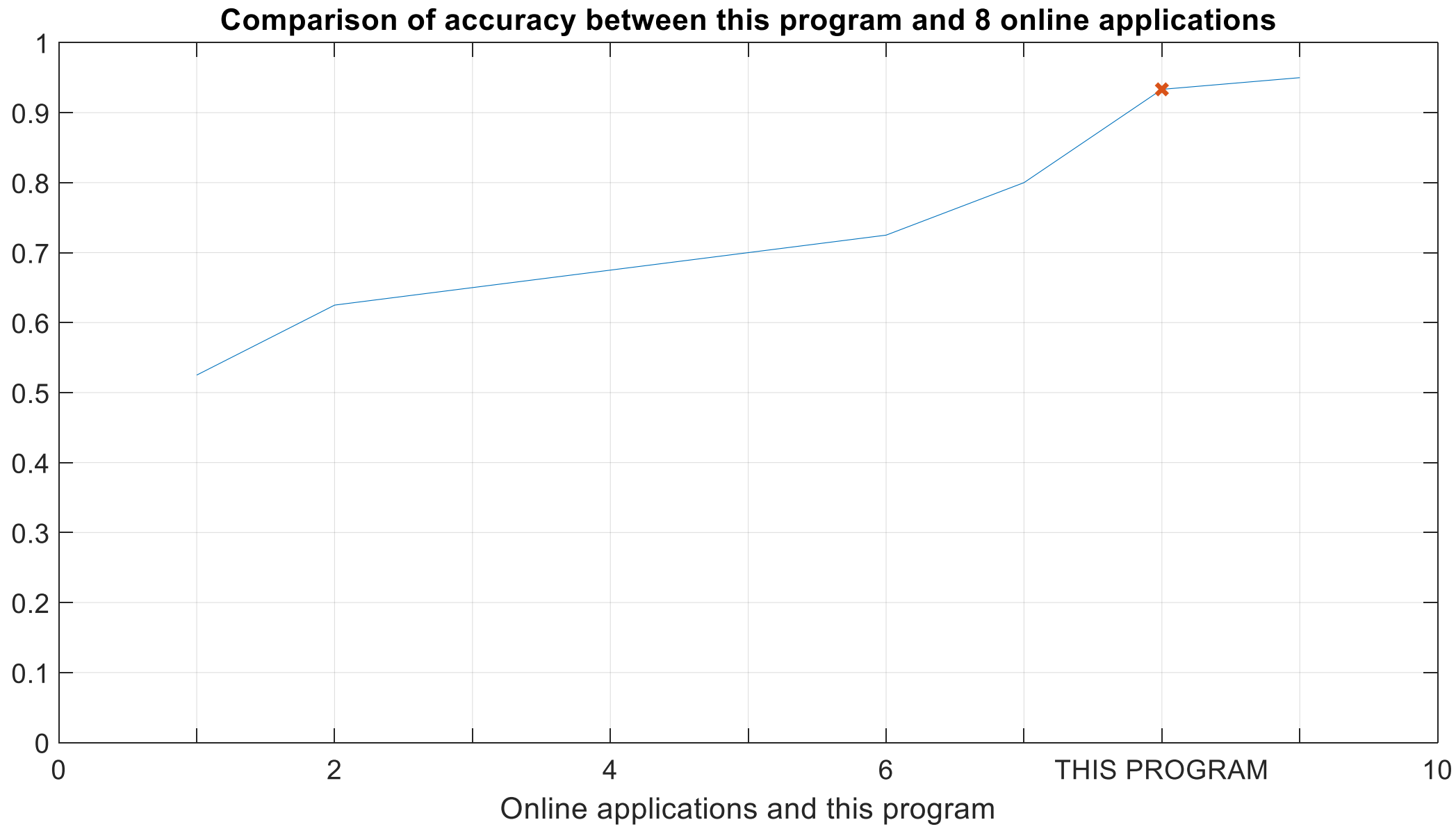
Accuracy across histogram post-processing method




Accuracy accross filter sizes in %
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10^1
10^2
10^3
10^4
10^5
Filter size


Music with and without drums accuracy by filter size
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10^1
10^2
10^3
10^4
10^5
Filter size
Without drums
With drums


Overall accuracy depending on type of music
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
85.15%
52.27%
With
Without


Comparison of accuracy between this program and 8 online applications
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
THIS PROGRAM
10
Online applications and this program

Further improvements

- optimizing other parameters such as frequency band values
- time domain partition analogous to frequency domain partition
- implementation in hardware

Thank you for your attention!