TEAM HI!

Signal Processing Project

IIIT Hyderabad

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2023102014

Electronics and Communication

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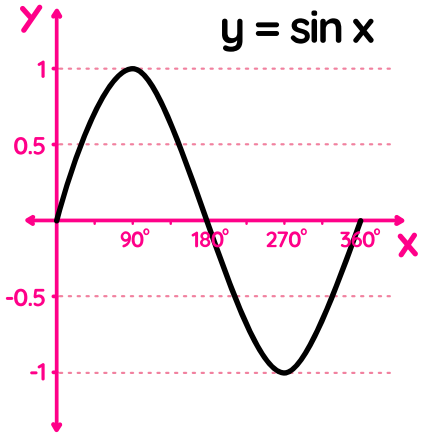
Electronics and Communication

Content Summary

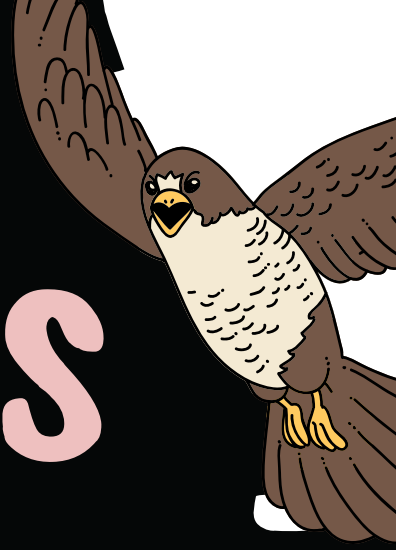


This project delves into three diverse areas: bird species identification, heart rate estimation, and speech loudness segmentation. Each part leverages the concepts of time-domain and frequency-domain signal analysis, feature extraction, and classification techniques to address real-world challenges.

Bird Recognition

THE PROJECT INVOLVES FEATURE EXTRACTION FROM BIRD SOUNDS TO DISTINGUISH SPECIES BASED ON THEIR UNIQUE AUDIO CHARACTERISTICS

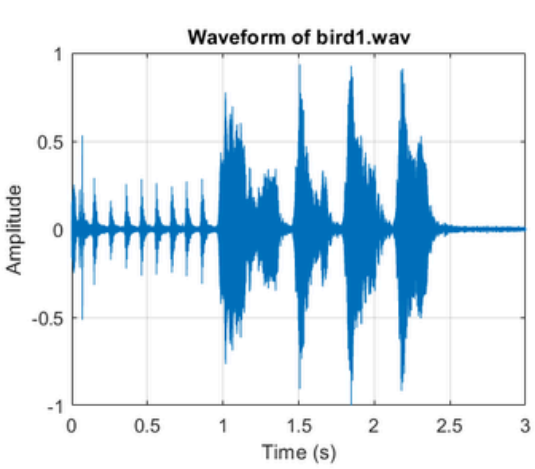
Correlations

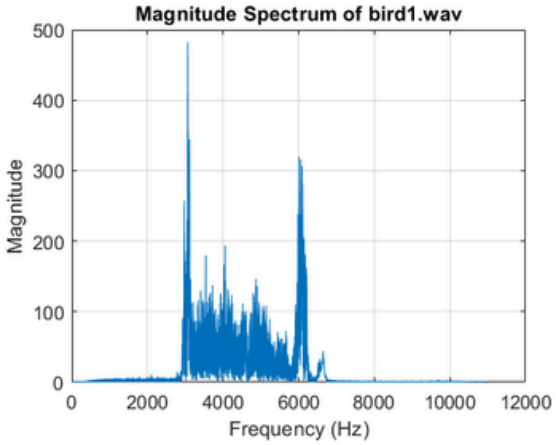


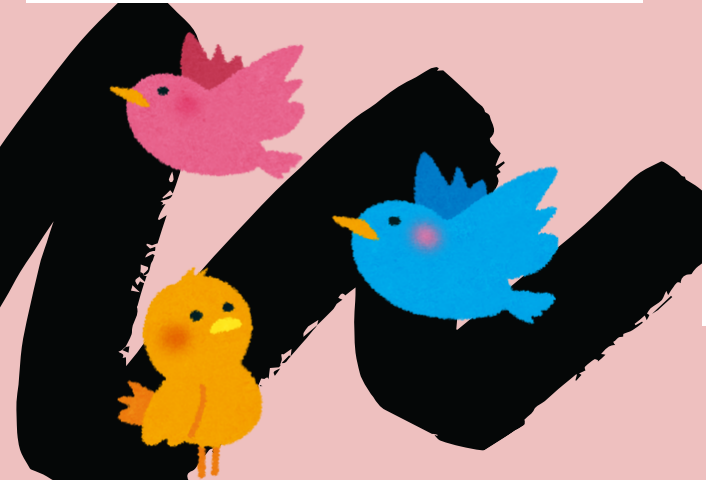
IN THIS PROBLEM, WE ARE USING THE CONCEPT OF CORRELATION OF TWO SIGNALS. CORRELATION IS A MATHEMATICAL OPERATION THAT MEASURES THE SIMILARITY BETWEEN TWO SIGNALS. MORE SPECIFICALLY, WE WILL USE THE CONCEPT OF CROSS-CORRELATION. IT MEASURES THE SIMILARITY BETWEEN TWO DIFFERENT SIGNALS AS A FUNCTION OF THE TIME LAG BETWEEN THEM. IT IS THE SAME AS CONVOLUTION OF THE TWO SIGNALS.

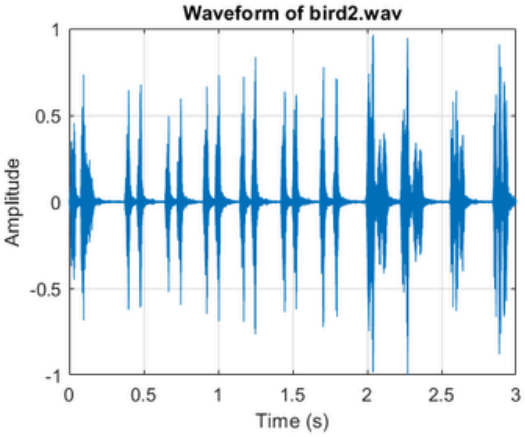
$$g(x) * f(x) = \int_{-\infty}^{\infty} f(t)g(x-t)dt$$

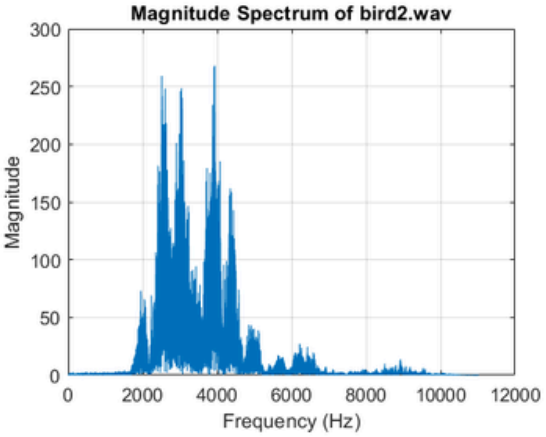
Analysis of Reference Signals

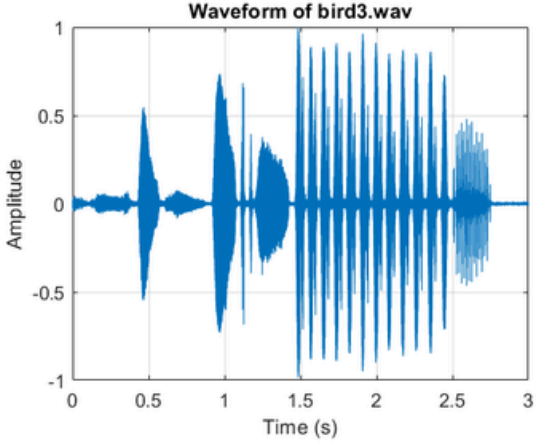


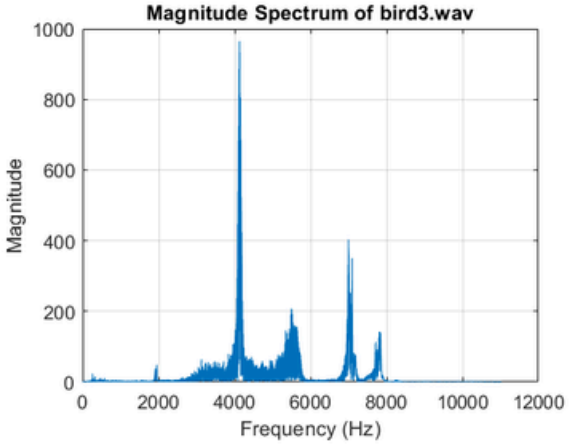




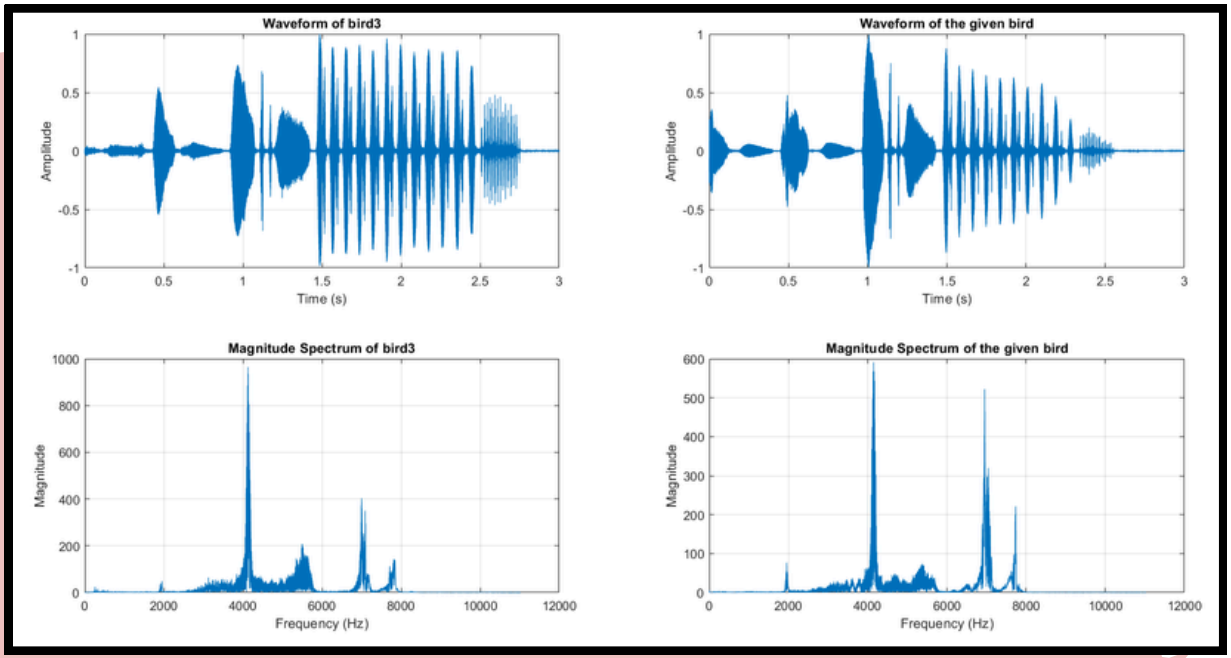


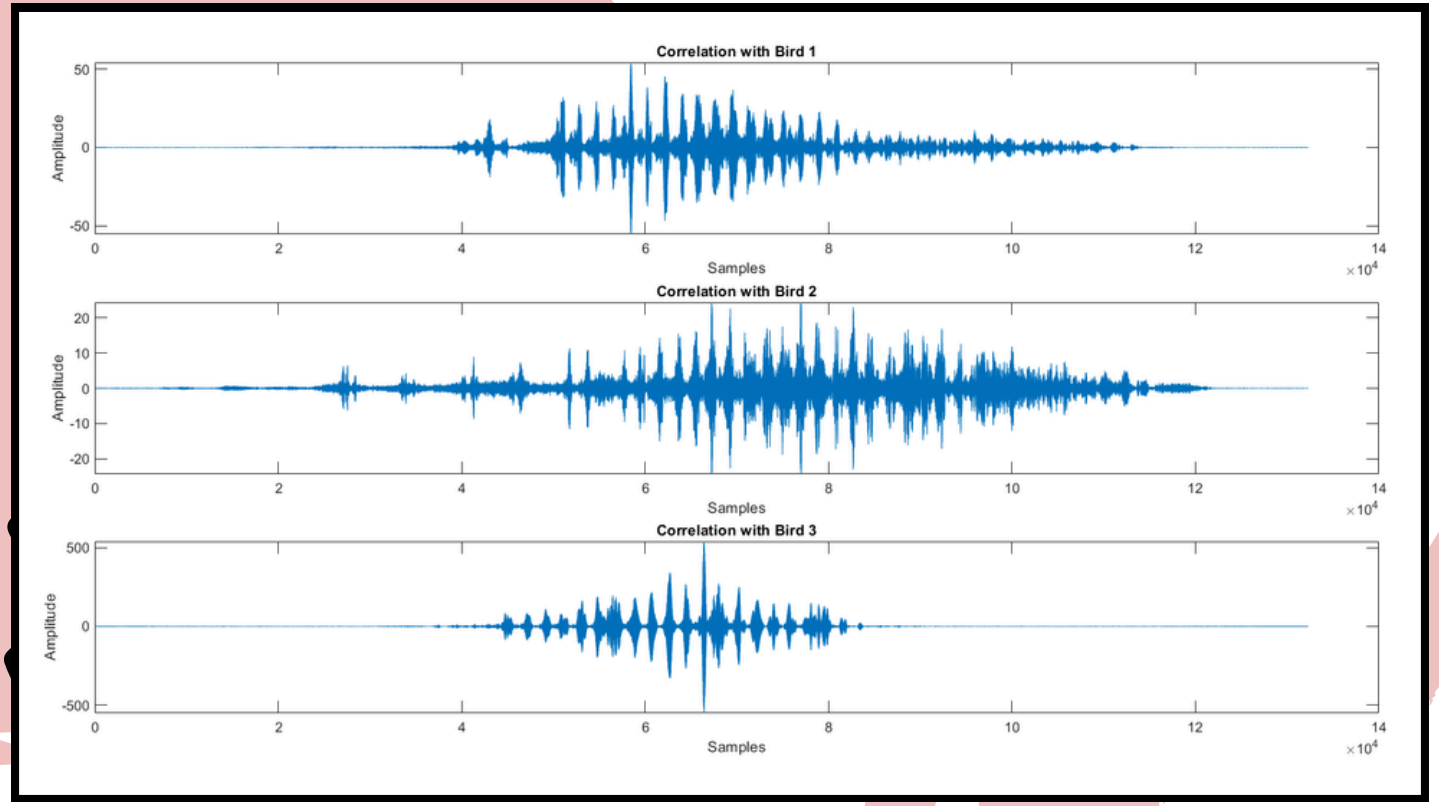




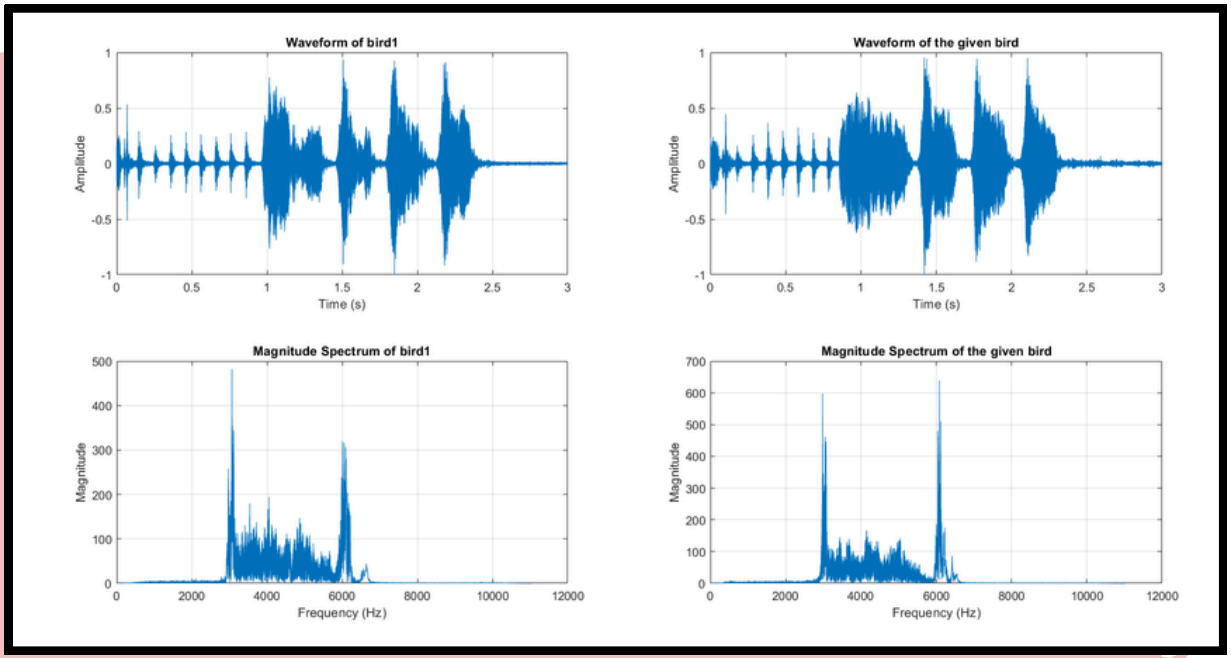


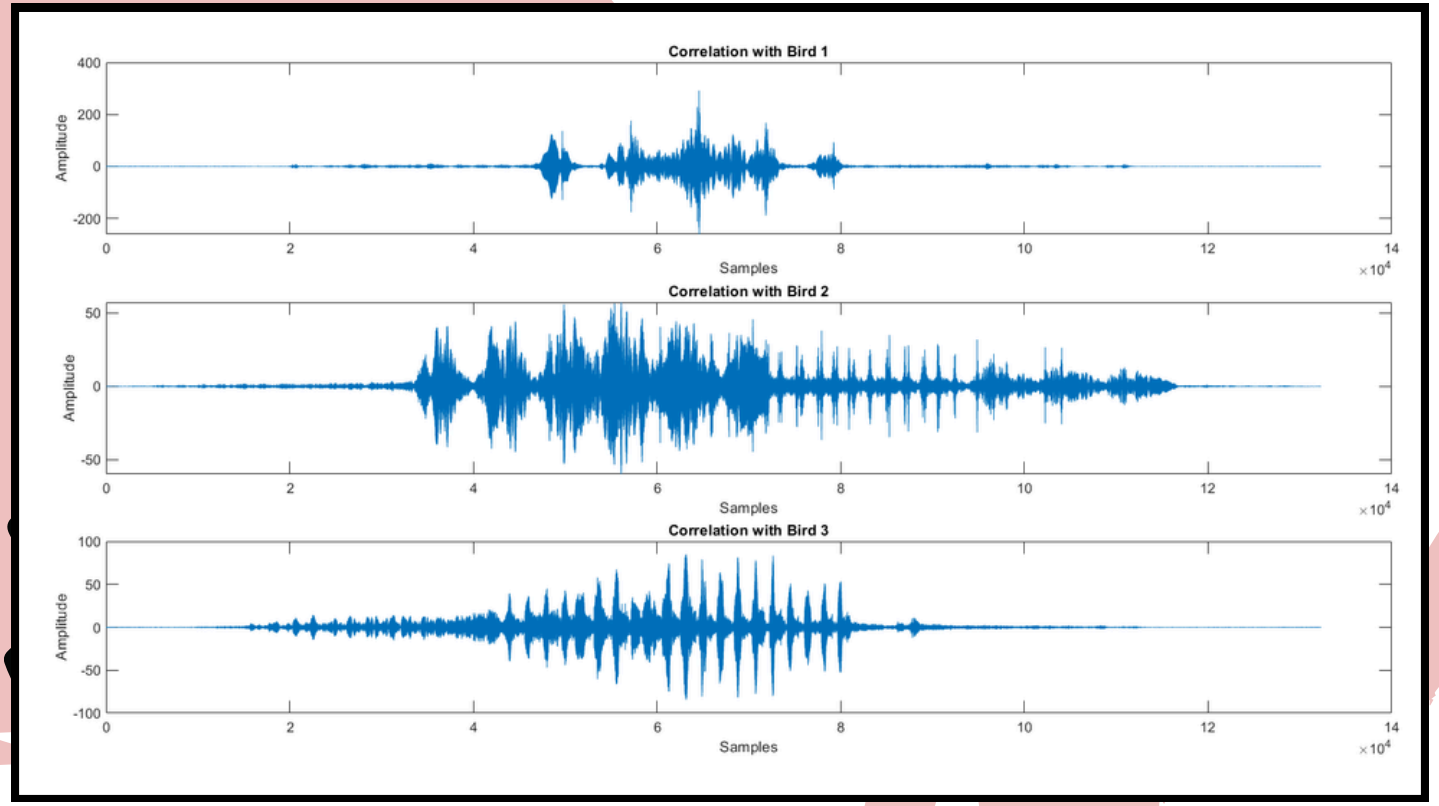
Sound Recognition Of F-1



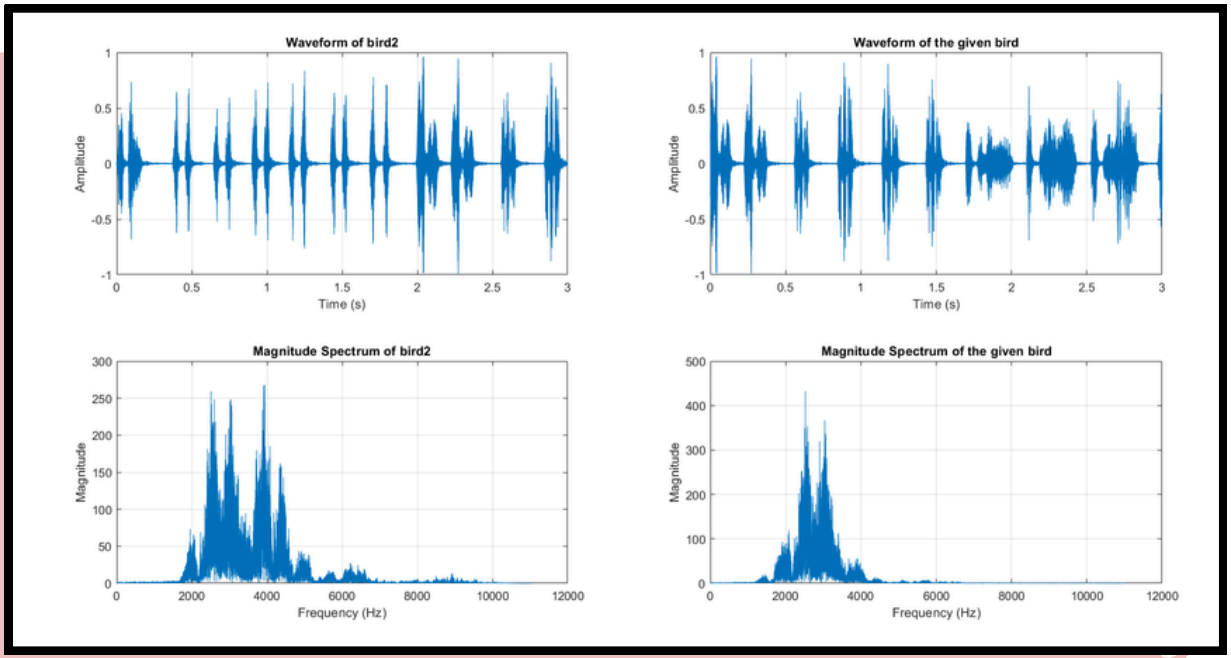


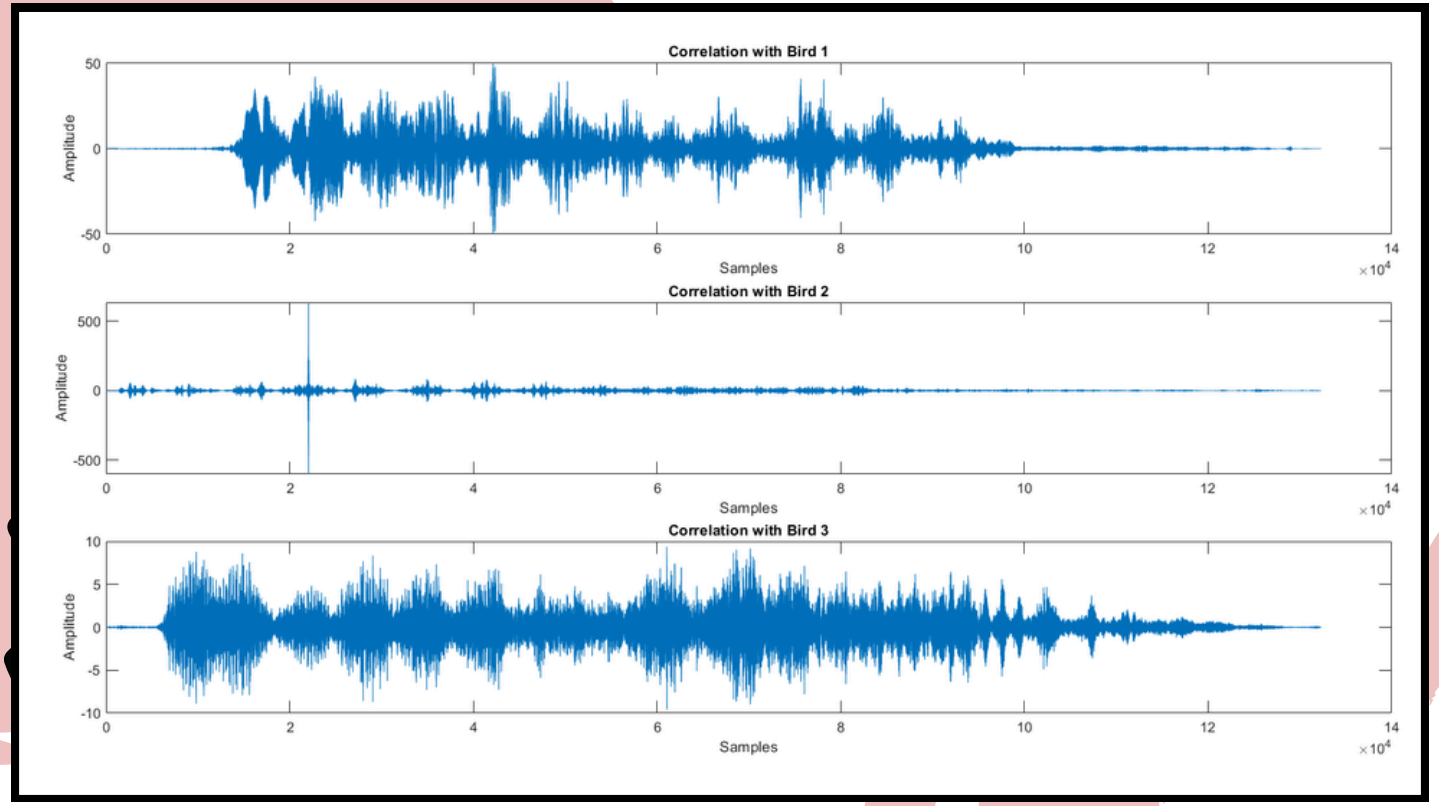
Sound Recognition Of F-2



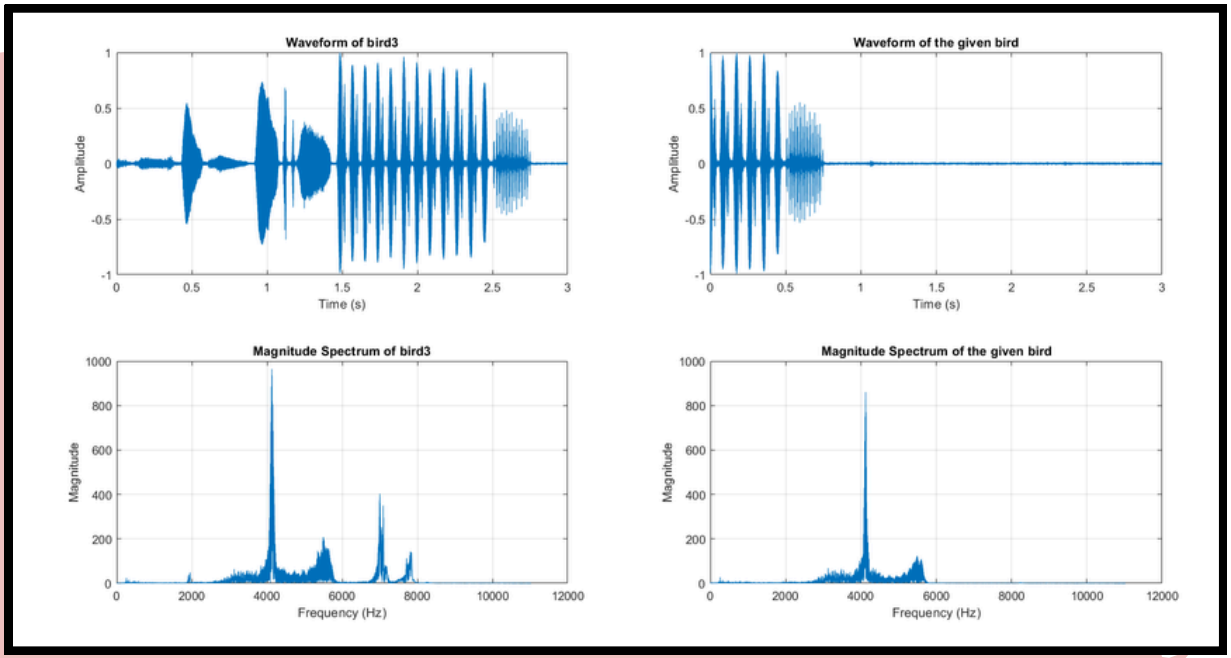


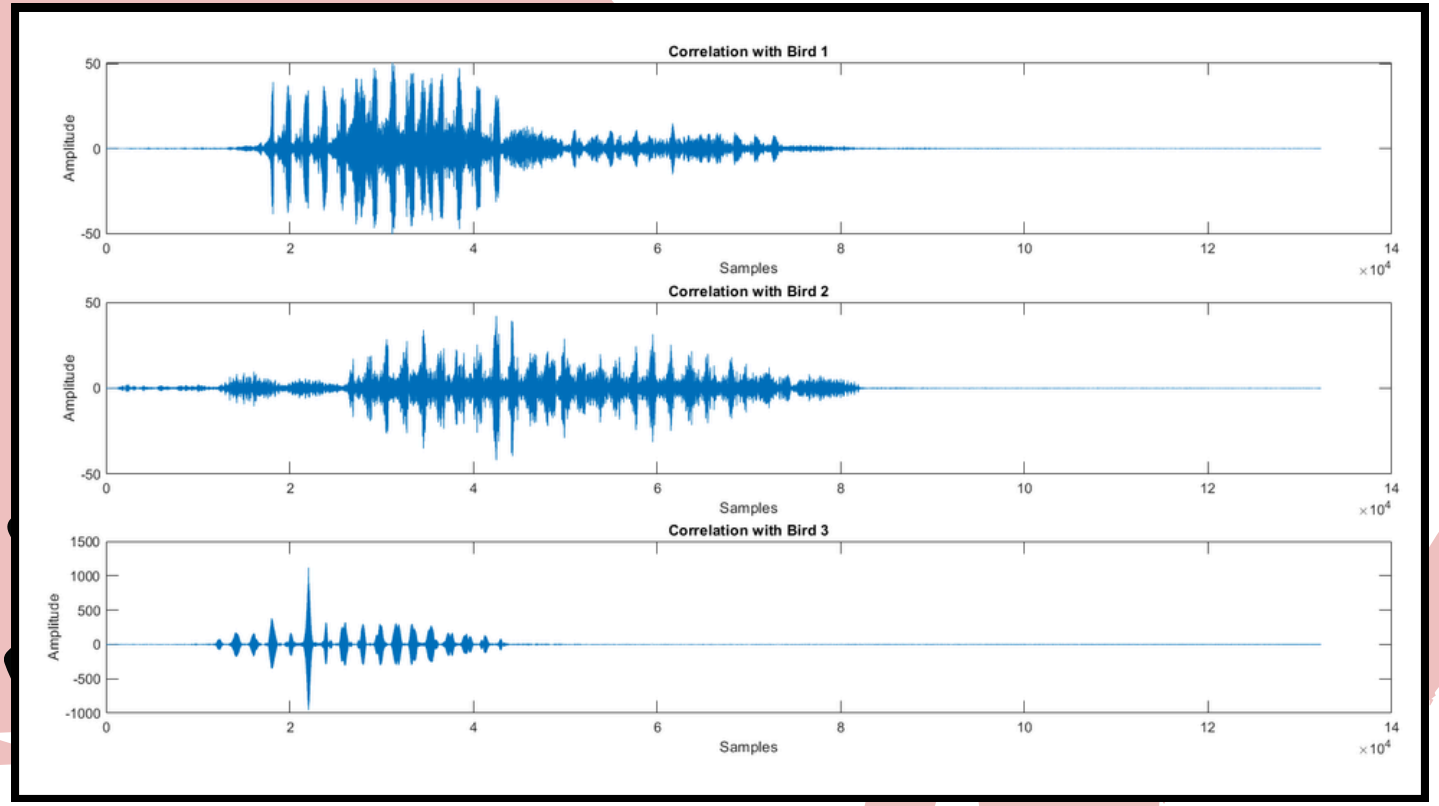
Sound Recognition Of F-3



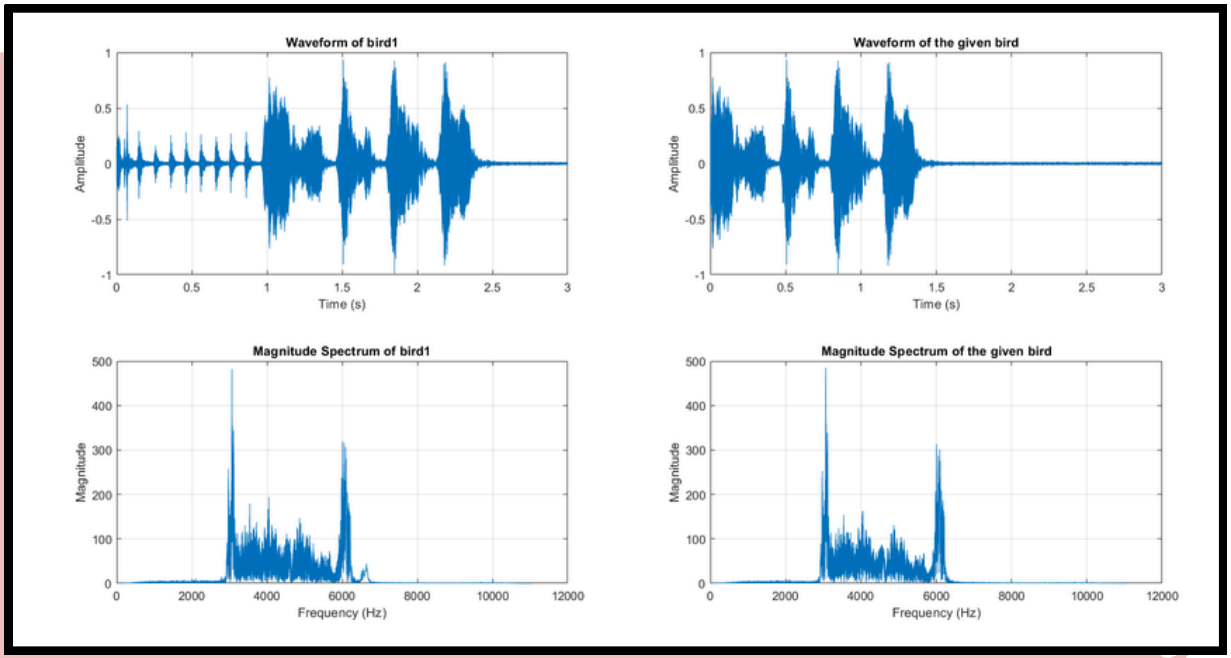


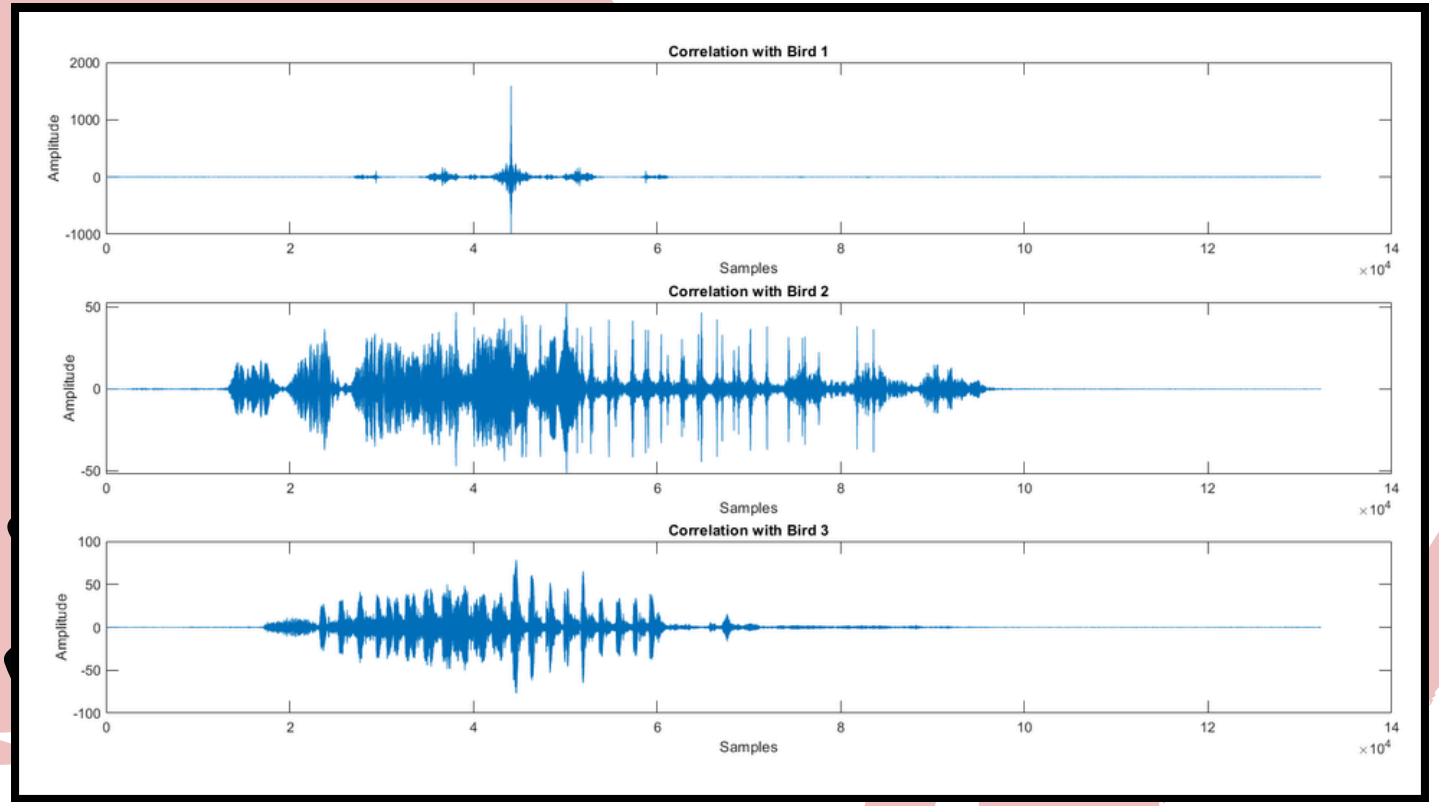
Sound Recognition Of F-4



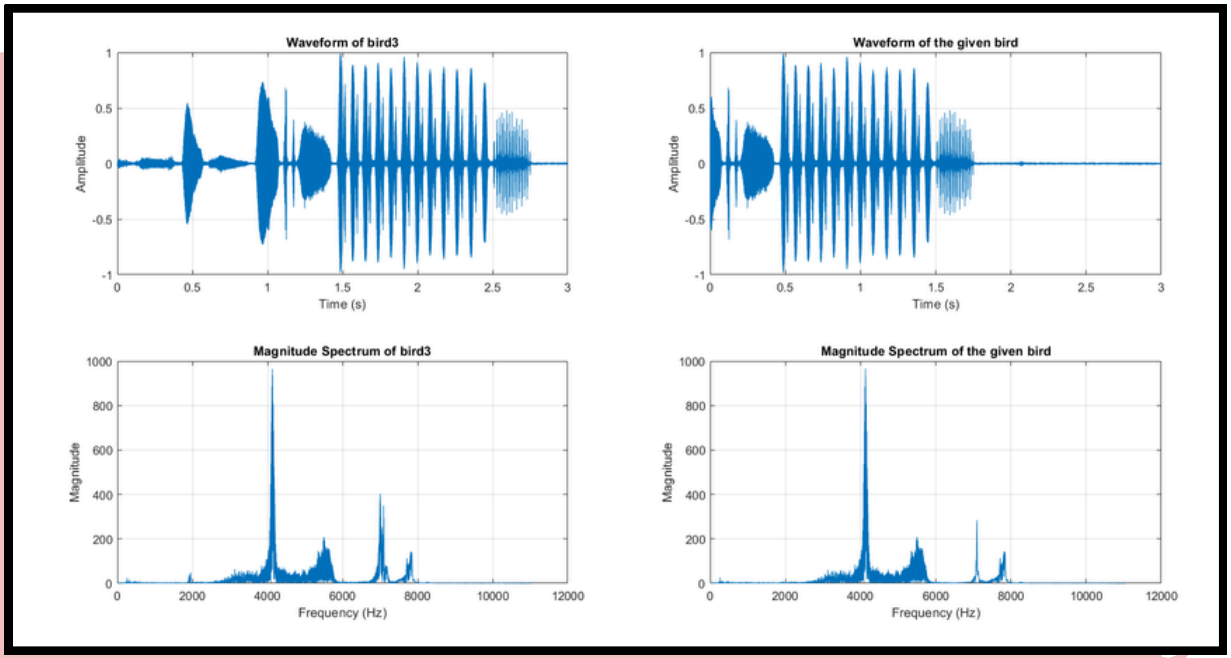


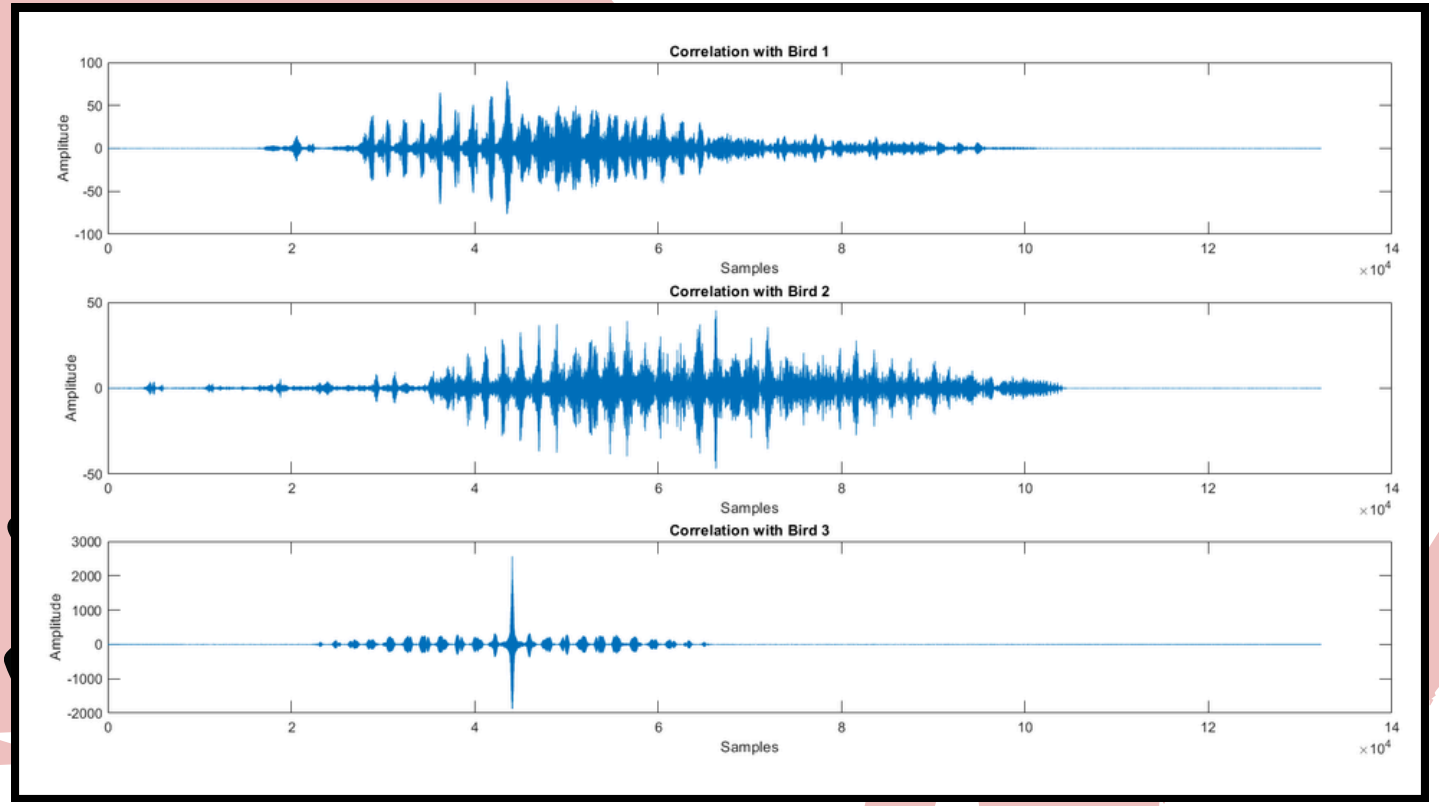
Sound Recognition Of F-5



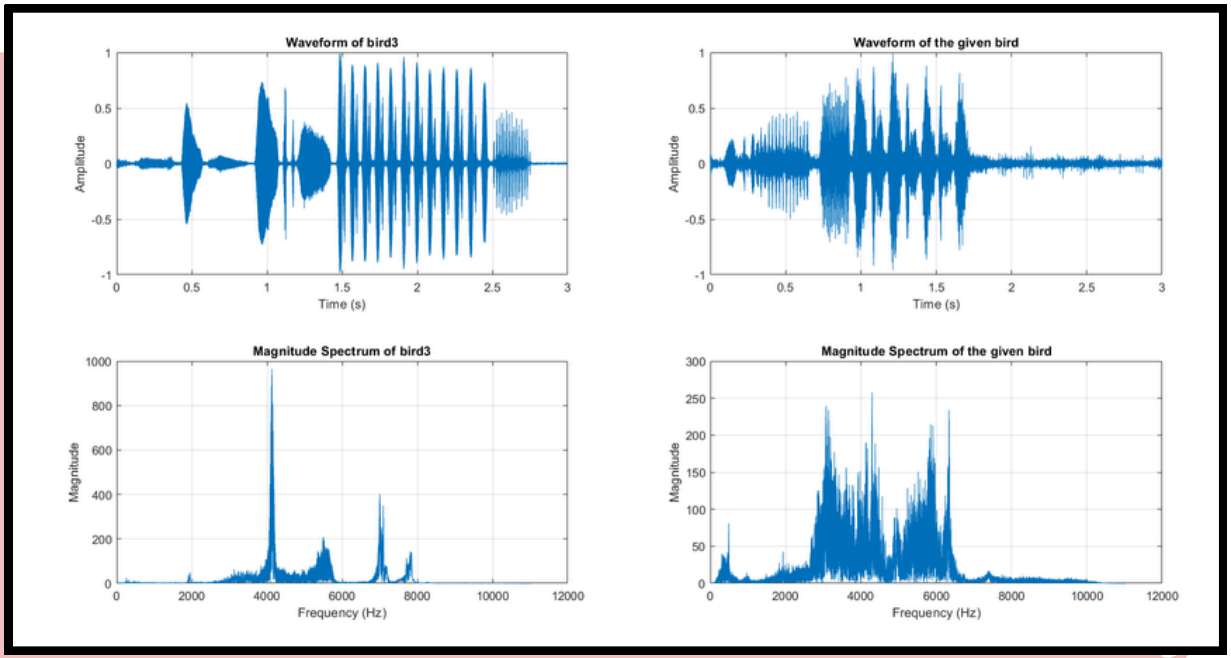


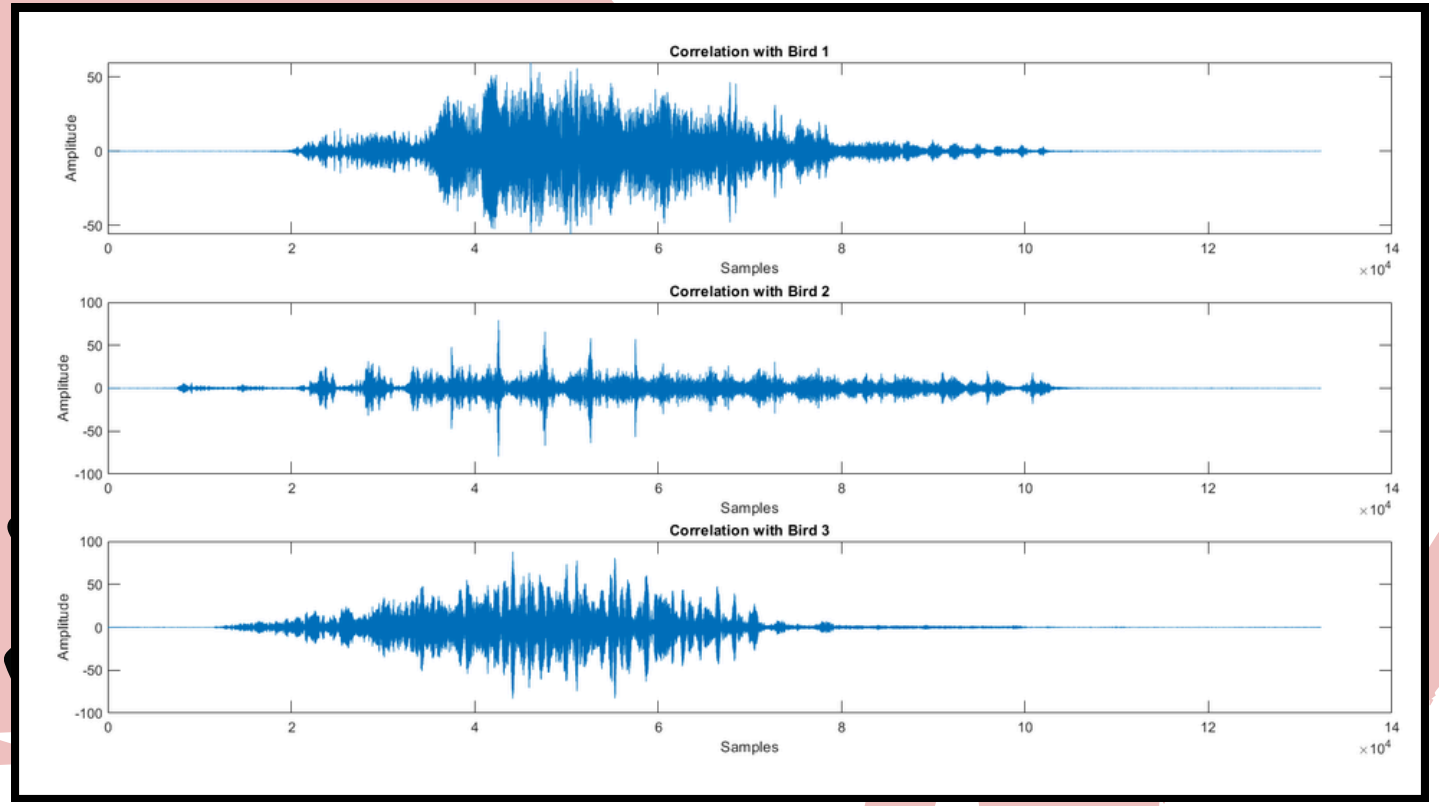
Sound Recognition Of F-6



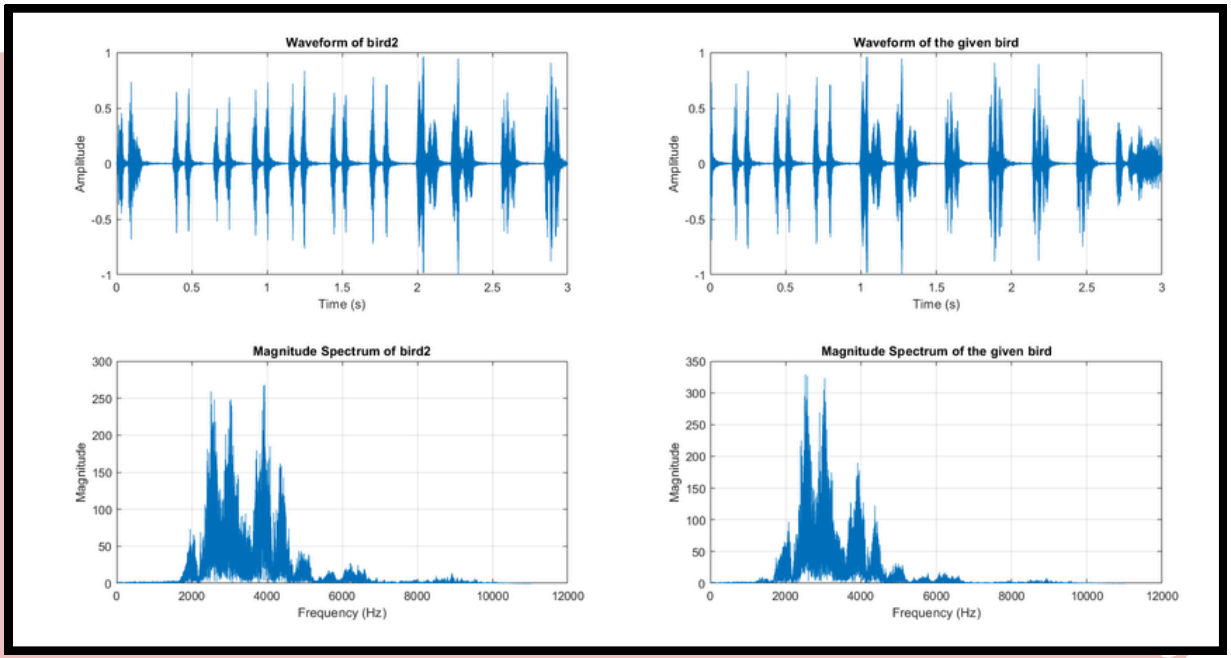


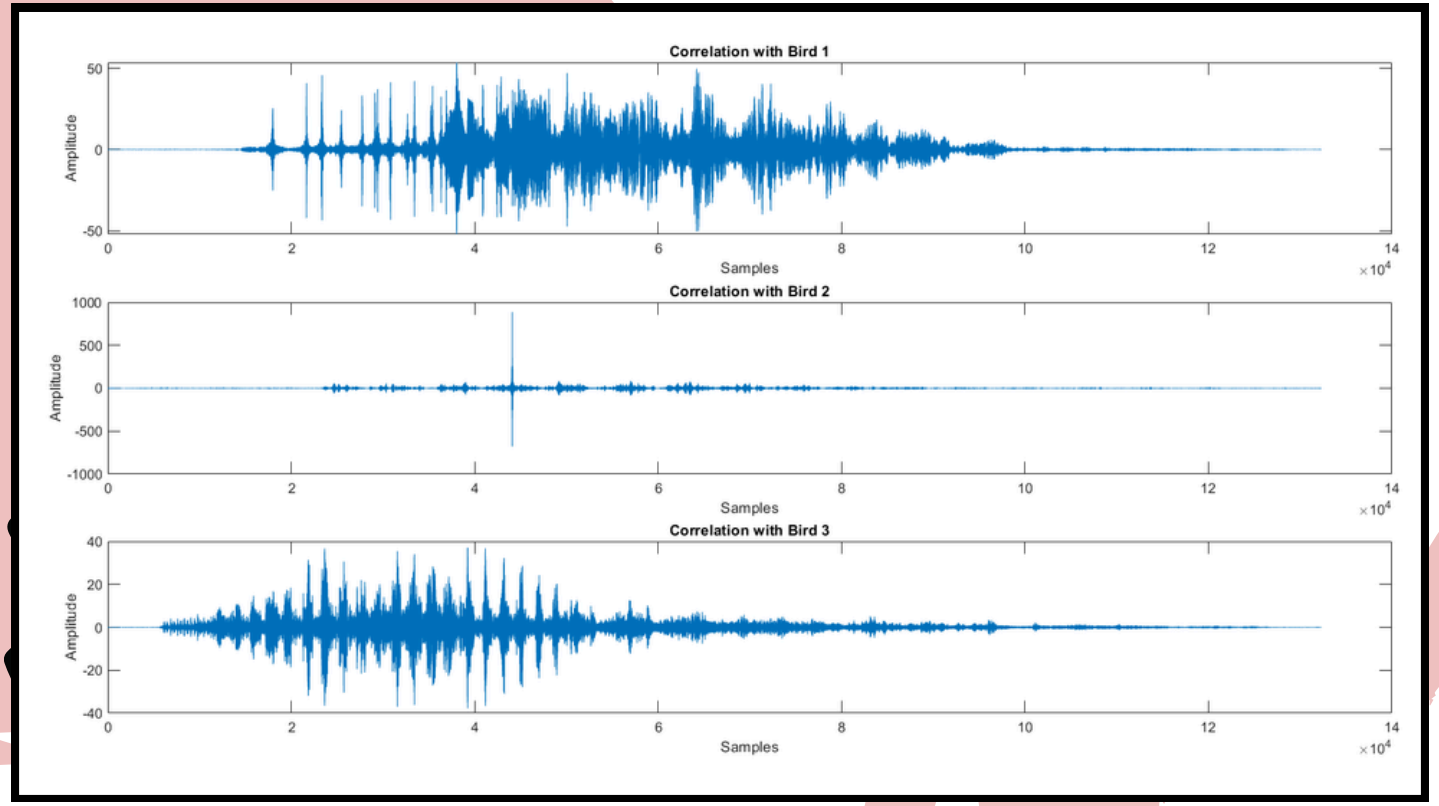
Sound Recognition Of F-7





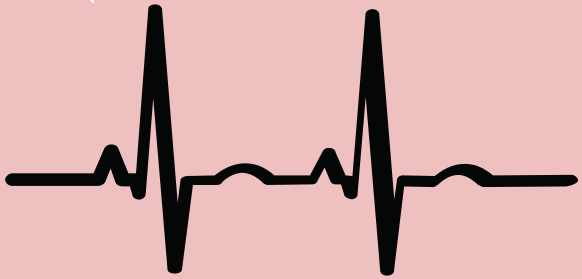
Sound Recognition Of F-8





RESULTS - SUMMARY

Input Signal	Detected Signal	Correlation Value
F1	Bird-3	540.4
F2	Bird-1	291.5
F3	Bird-2	634.4
F4	Bird-3	1116.9
F5	Bird-1	1593.2
F6	Bird-3	2565.1
F7	Bird-3	87.9
F8	Bird-2	886.4

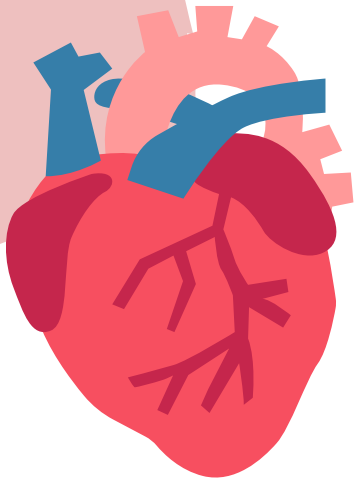


Heart Rate Estimation

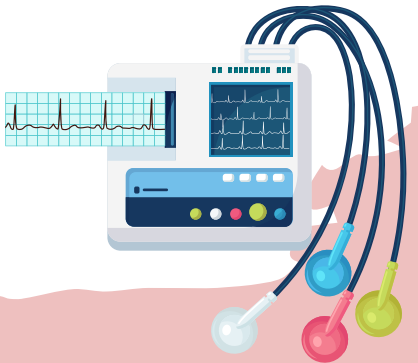
ELECTROCARDIOGRAM (ECG) SIGNALS ARE HEART SIGNALS (ELECTRICAL ACTIVITY OF THE HEART) ROUTINELY USED TO MONITOR HEART HEALTH. HEART RATE (HR) IS AN IMPORTANT PARAMETER USED FOR HEALTH ASSESSMENT. THE ECG IS A QUASI-PERIODIC SIGNAL, AND THE HR TYPICALLY VARIES OVER TIME BASED ON THE ACTIVITY INVOLVED.

Part 1:

{Signal Acquisition and Processing Phenomenon}

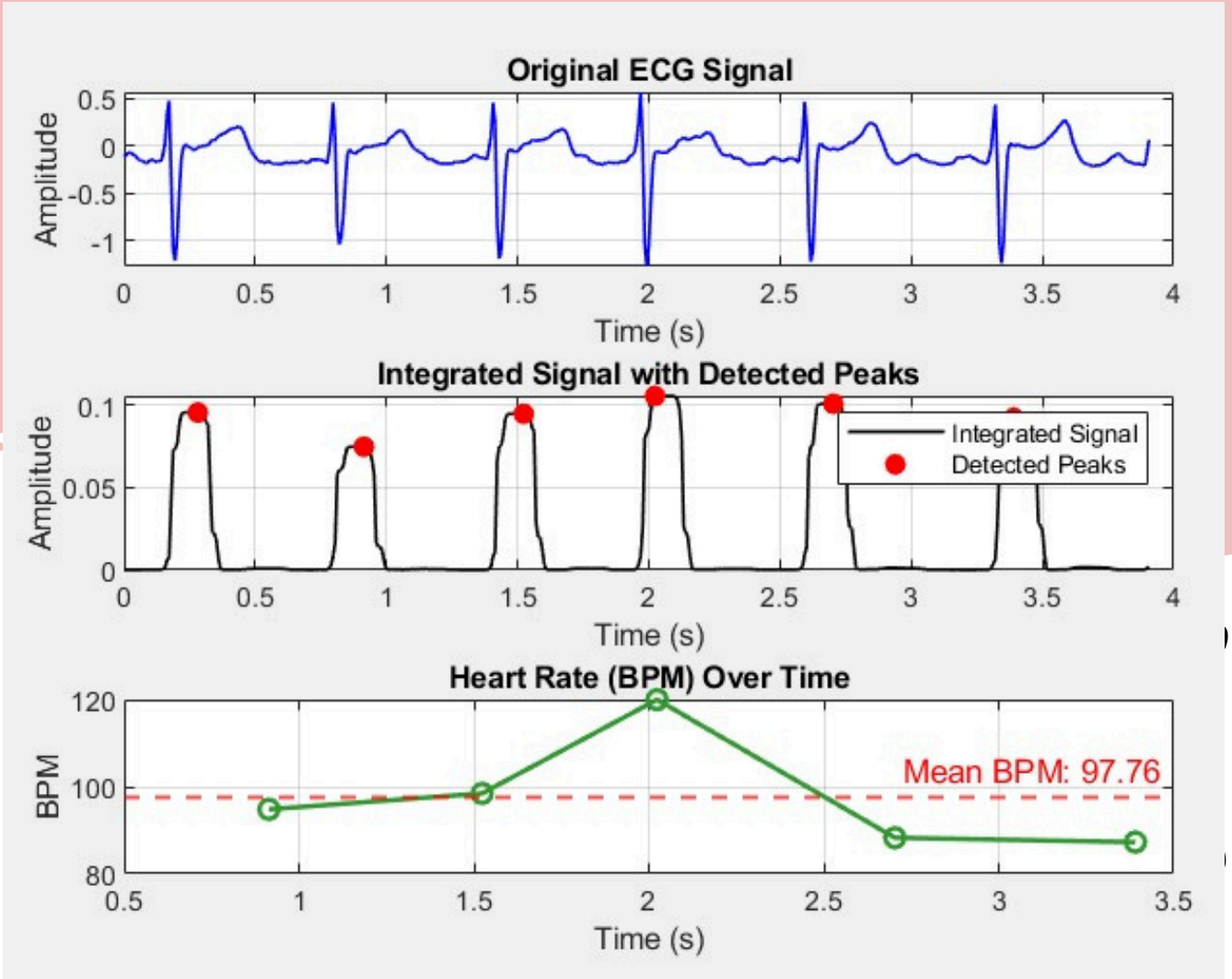


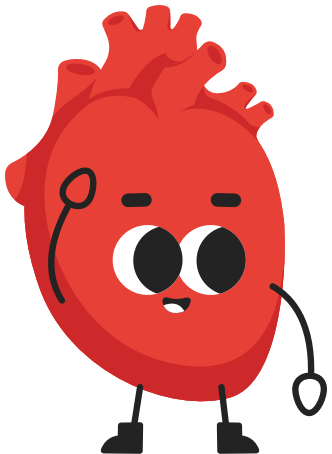
ELECTRICAL ACTIVITY OF THE HEART (ECG SIGNAL), RECORDED AS A TIME-VARYING VOLTAGE DUE TO THE DEPOLARIZATION AND REPOLARIZATION OF CARDIAC MUSCLE CELLS. THE ECG SIGNAL EXHIBITS DISTINCT WAVEFORMS (P, QRS, T) CORRESPONDING TO THE CARDIAC CYCLE. SIGNAL PROCESSING IS USED TO ENHANCE AND ANALYZE THESE WAVEFORMS FOR FEATURE EXTRACTION.



Heart Rate Estimation

```
--- Heart Rate Analysis ---
Total Peaks Detected: 6
Average Heart Rate (BPM): 97.765
```

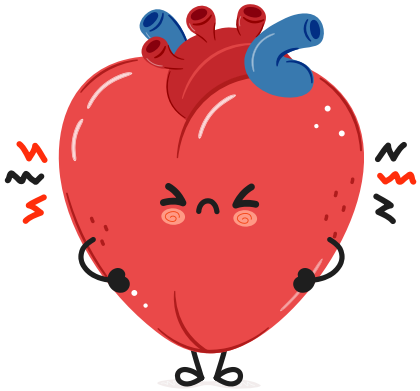




Part 2:

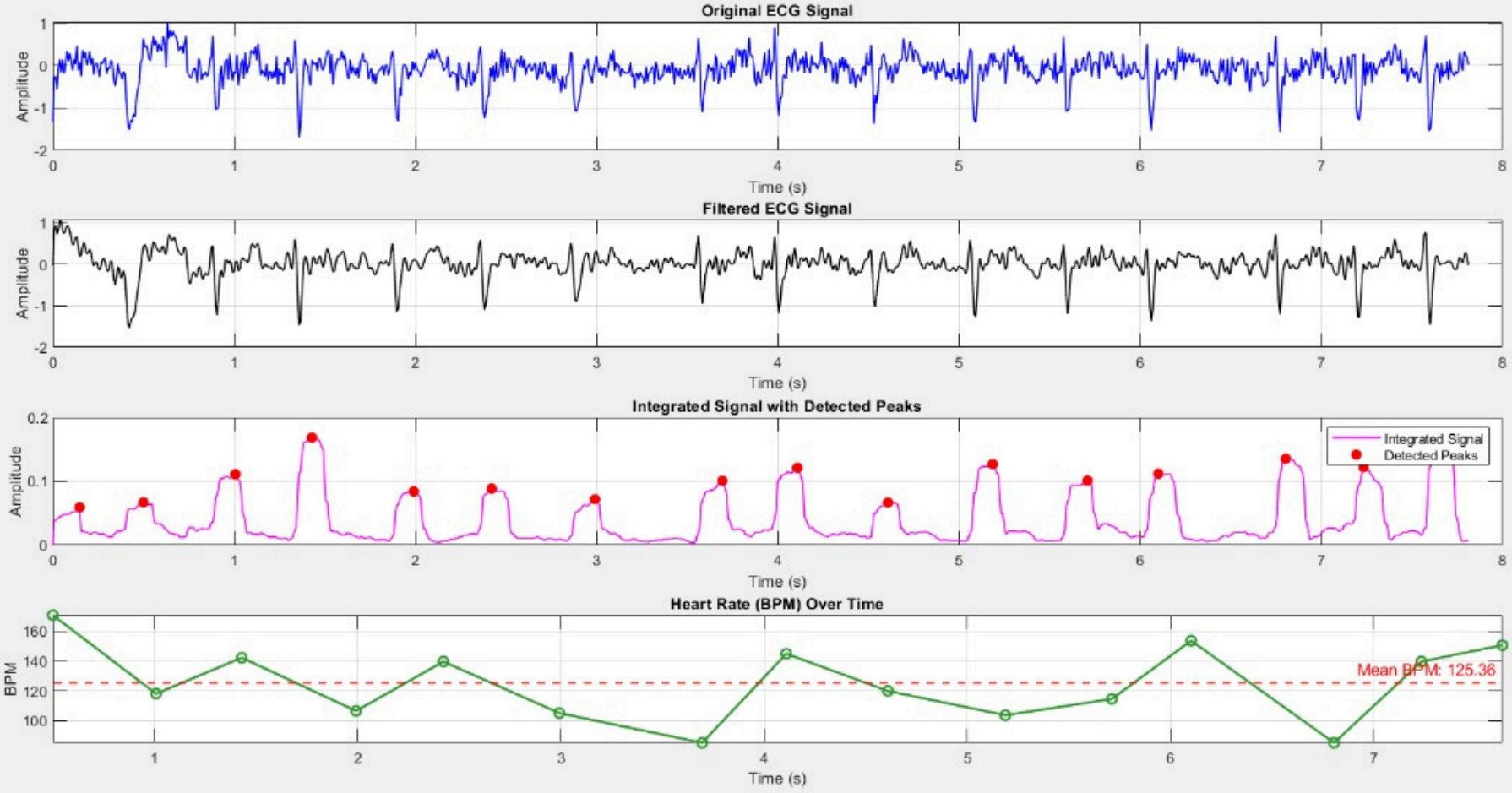
Noise Removal & HR- Estimation

The heart rate is derived from the quasi-periodic nature of the ECG signal, where the R-peaks represent the most prominent feature in the QRS complex, corresponding to ventricular depolarization.



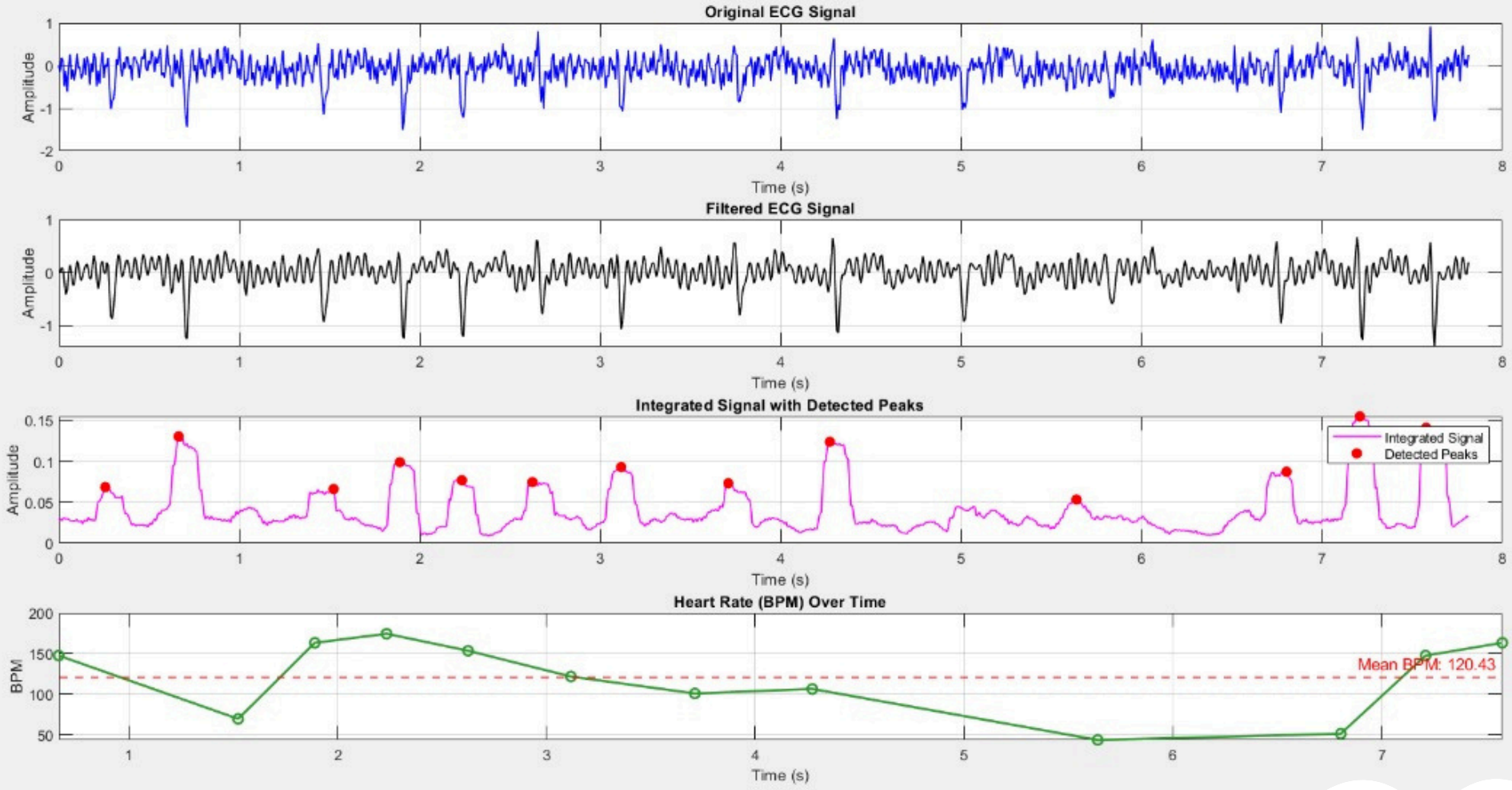
By measuring the time intervals between successive R-peaks (R-R intervals), we calculate the heart rate in beats per minute (BPM). Preprocessing removes noise to ensure accurate R-peak detection.

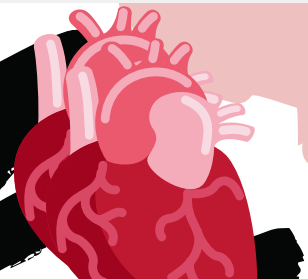
Filtering and Estimation - Signal 2




```
--- Heart Rate Analysis for E2 ---
Total Peaks Detected: 16
Average Heart Rate (BPM): 125.36
```

Filtering and Estimation - Signal 3





```
--- Heart Rate Analysis for E3 ---
Total Peaks Detected: 13
Average Heart Rate (BPM): 120.43
```

Loudness Segmentation

Speech is a natural mode of communication to convey the feelings and intentions. These intentions will be passed by changing loudness of the words spoken in one's speech. Often, the words in speech have strong perceptual boundaries however similar strong indications can't be observed in the speech signal

PART - 1

{ENERGY ANALYSIS}

ENERGY ANALYSIS IN SIGNAL PROCESSING IS A FUNDAMENTAL TECHNIQUE FOR ANALYZING THE AMPLITUDE OF A SIGNAL OVER TIME. IN THE CONTEXT OF SPEECH OR AUDIO SIGNALS, IT HELPS MEASURE THE "LOUDNESS" OF DIFFERENT SEGMENTS OF THE SIGNAL.

$$E_{\text{frame}} = \sum_{n=0}^{M-1} x[n]^2$$

Signal Energy

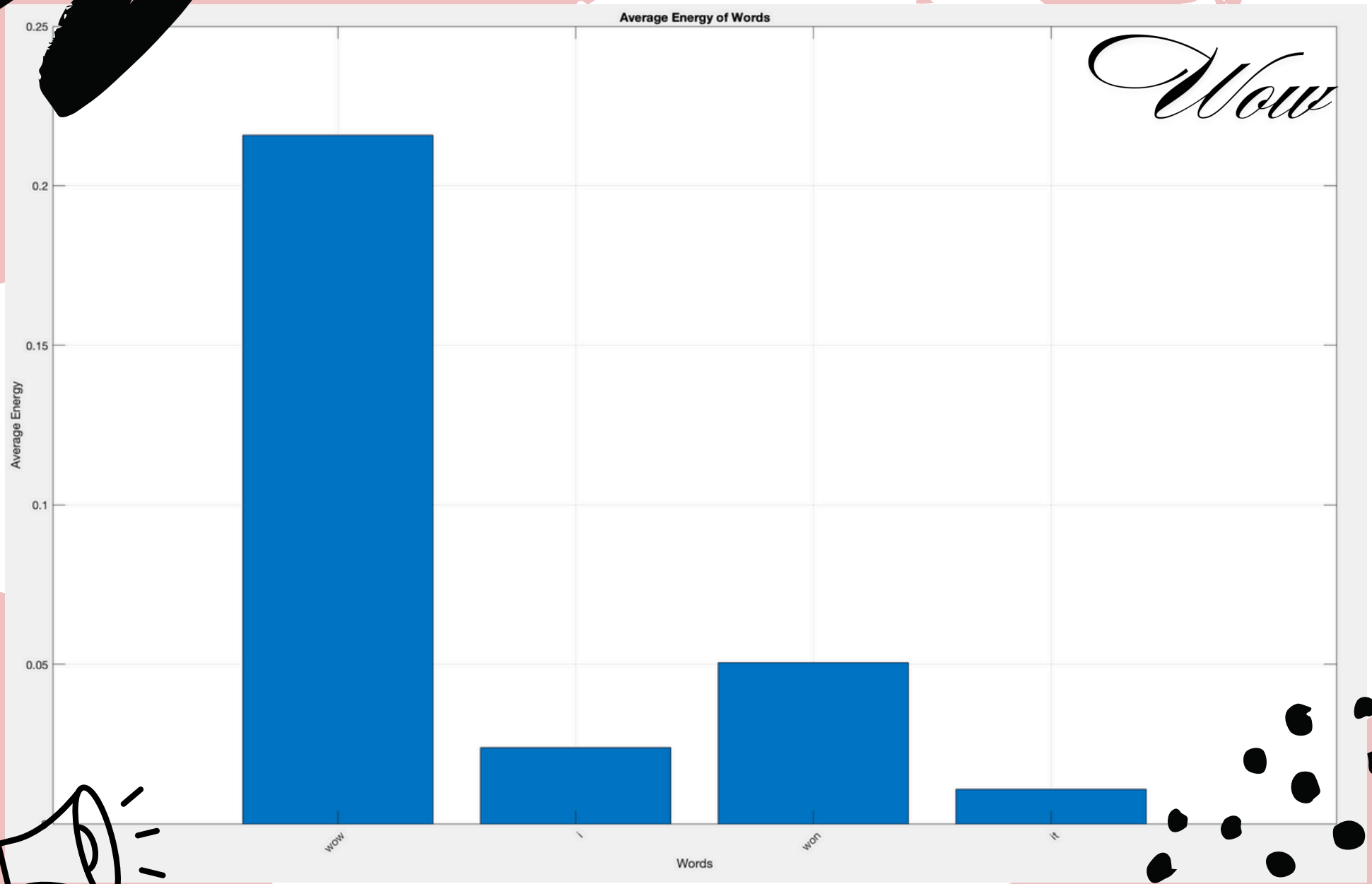
The energy of a signal over a given time period is defined as the sum of the squares of the signal's amplitude values.

$$E_{\text{normalized}} = \frac{E_{\text{frame}}}{\max(E_{\text{frame}})}$$

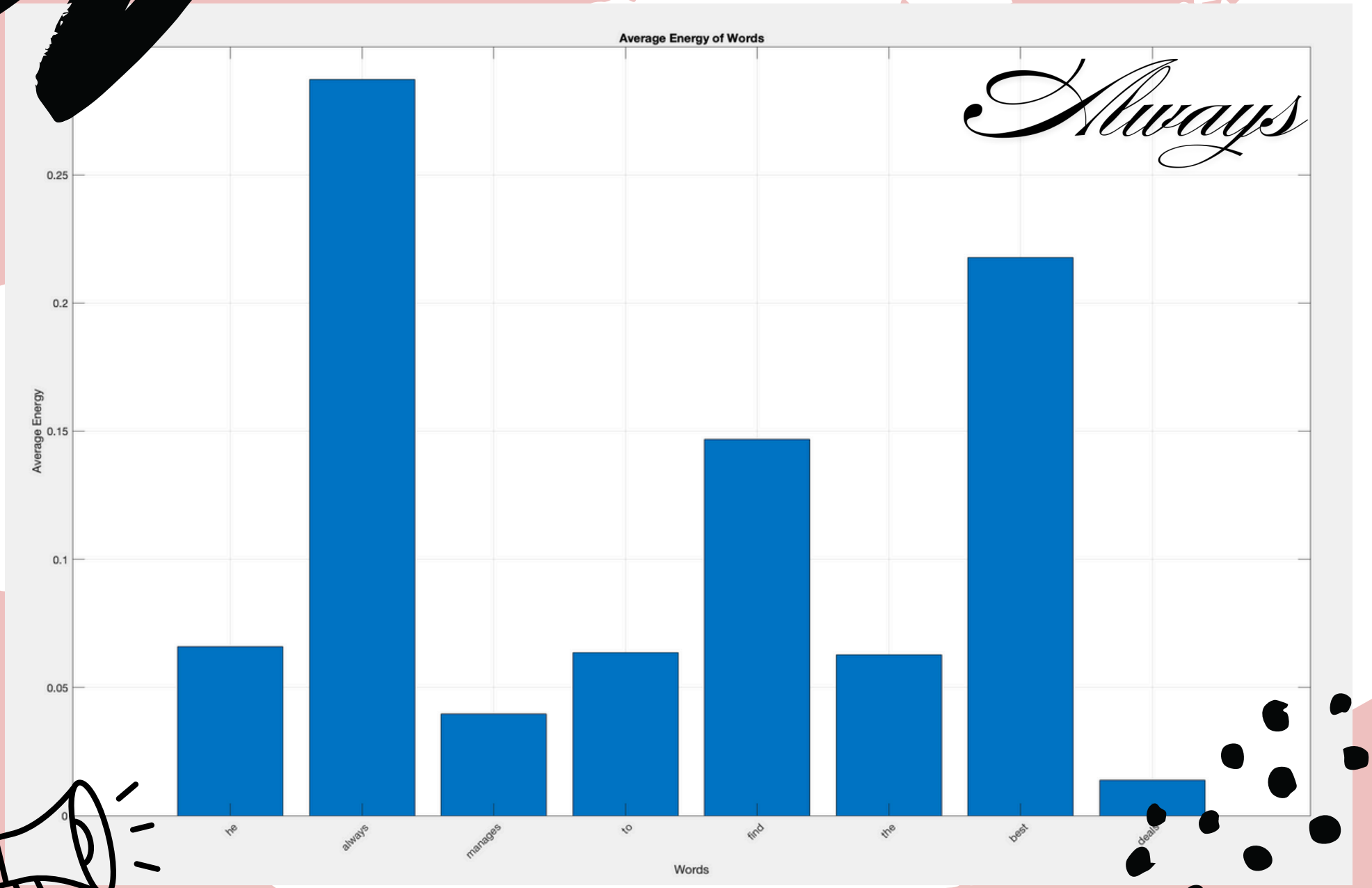
Normalization

To make energy values comparable across different audio signals, the energy can be normalized.

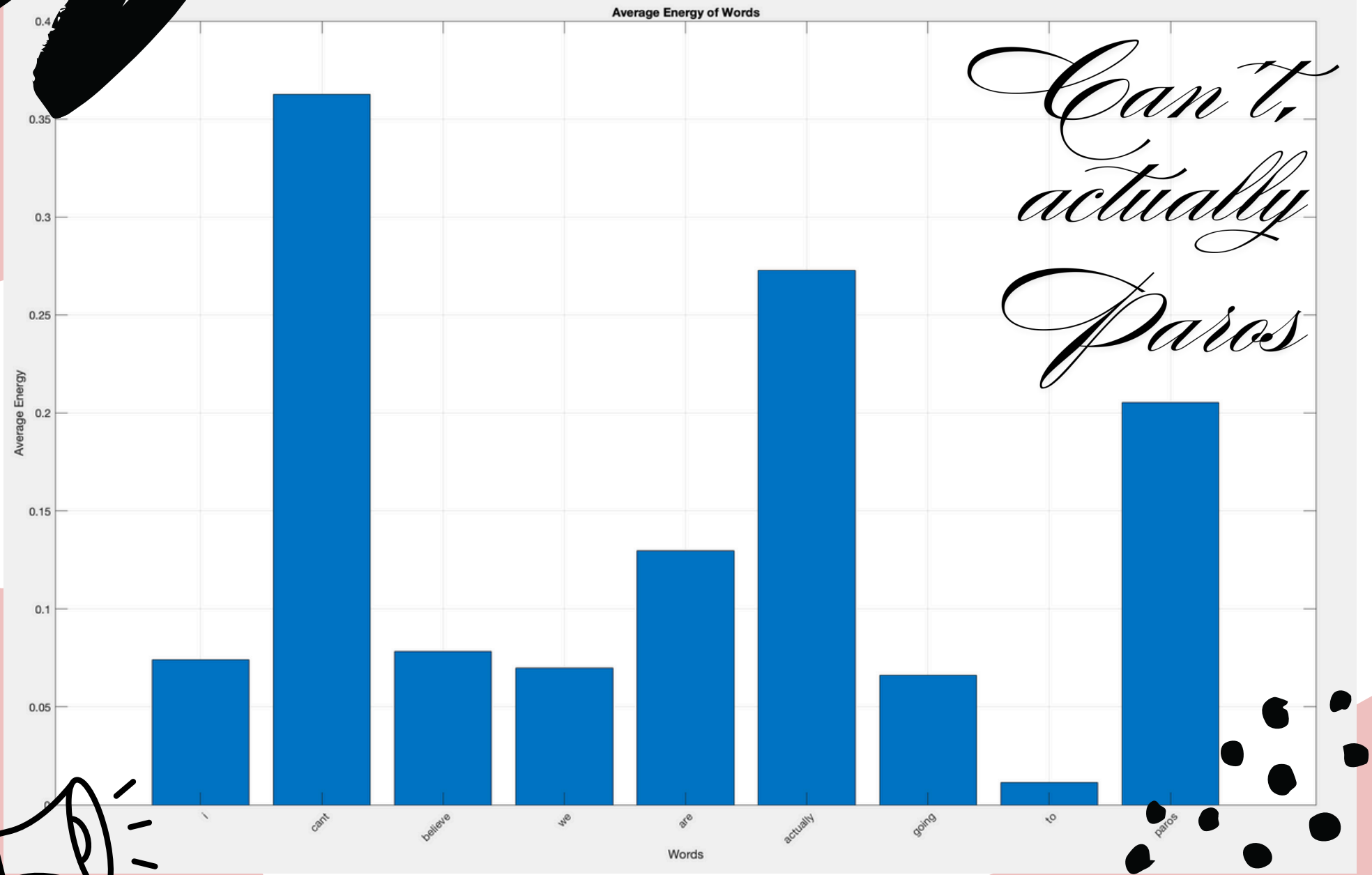
LOUDER WORDS FOR SIGNAL-1



LOUDER WORDS FOR SIGNAL-2

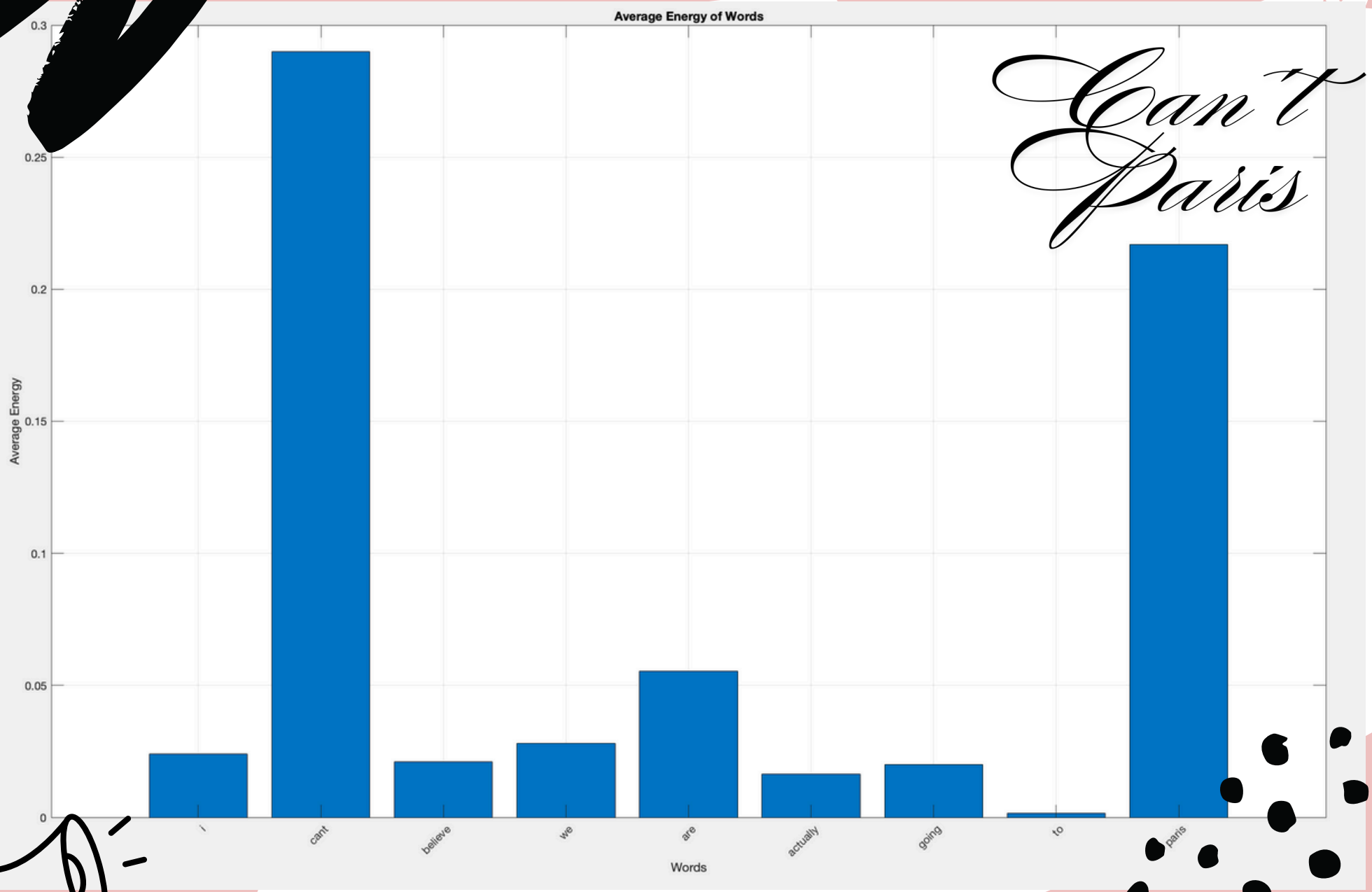


LOUDER WORDS FOR SIGNAL-3



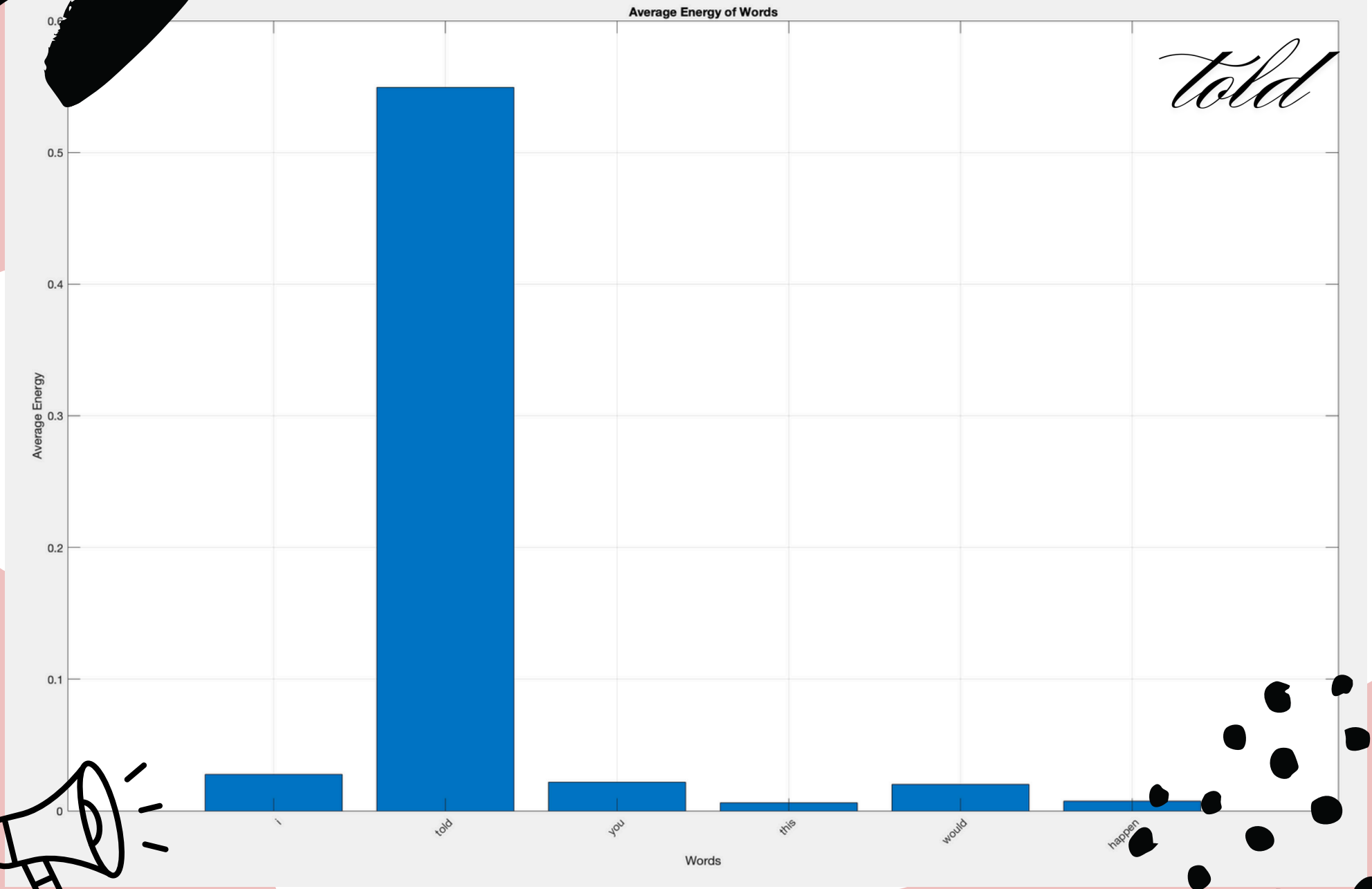
Can't actually Paros

LOUDER WORDS FOR SIGNAL-4

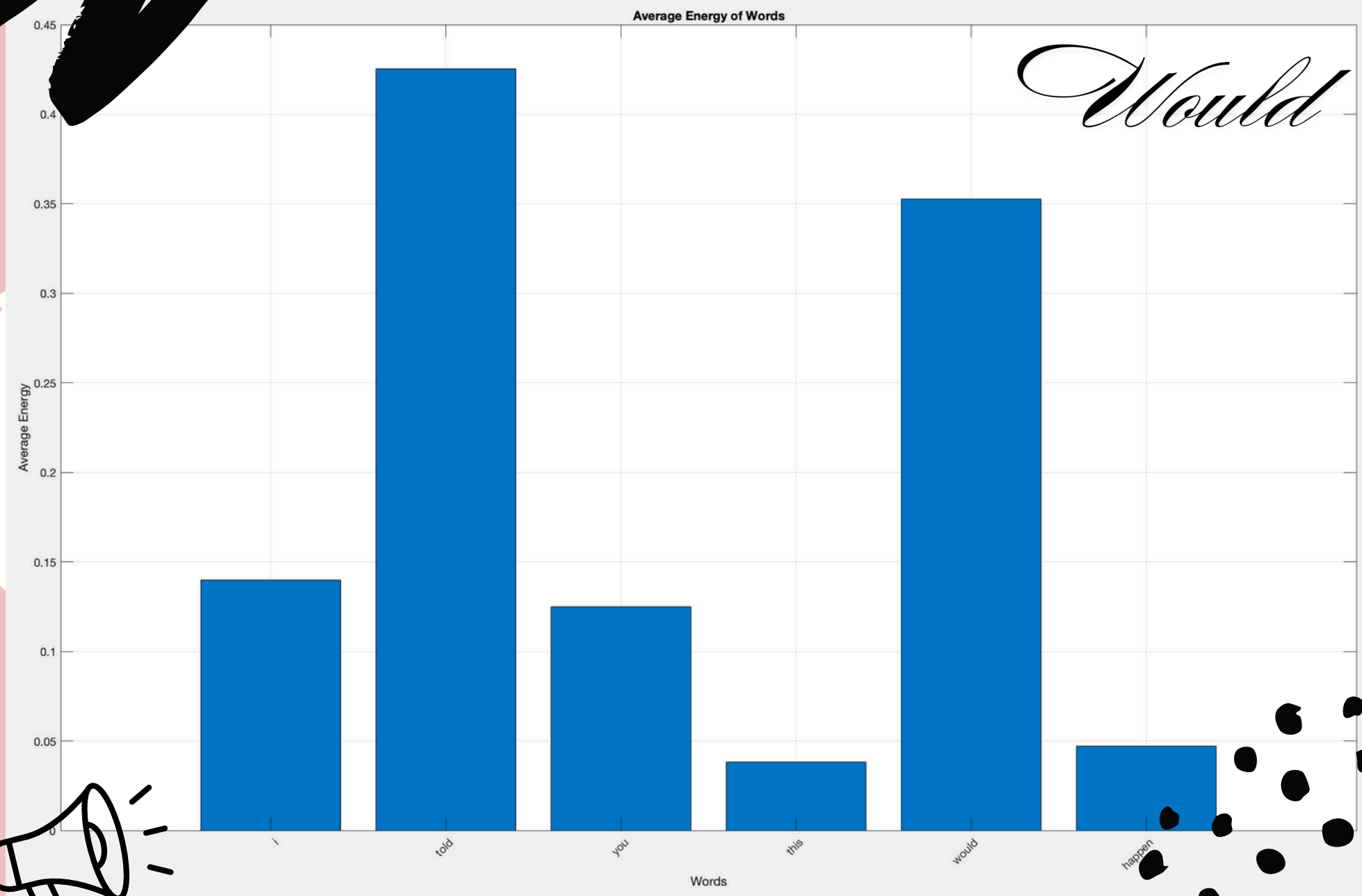


Can't Paris

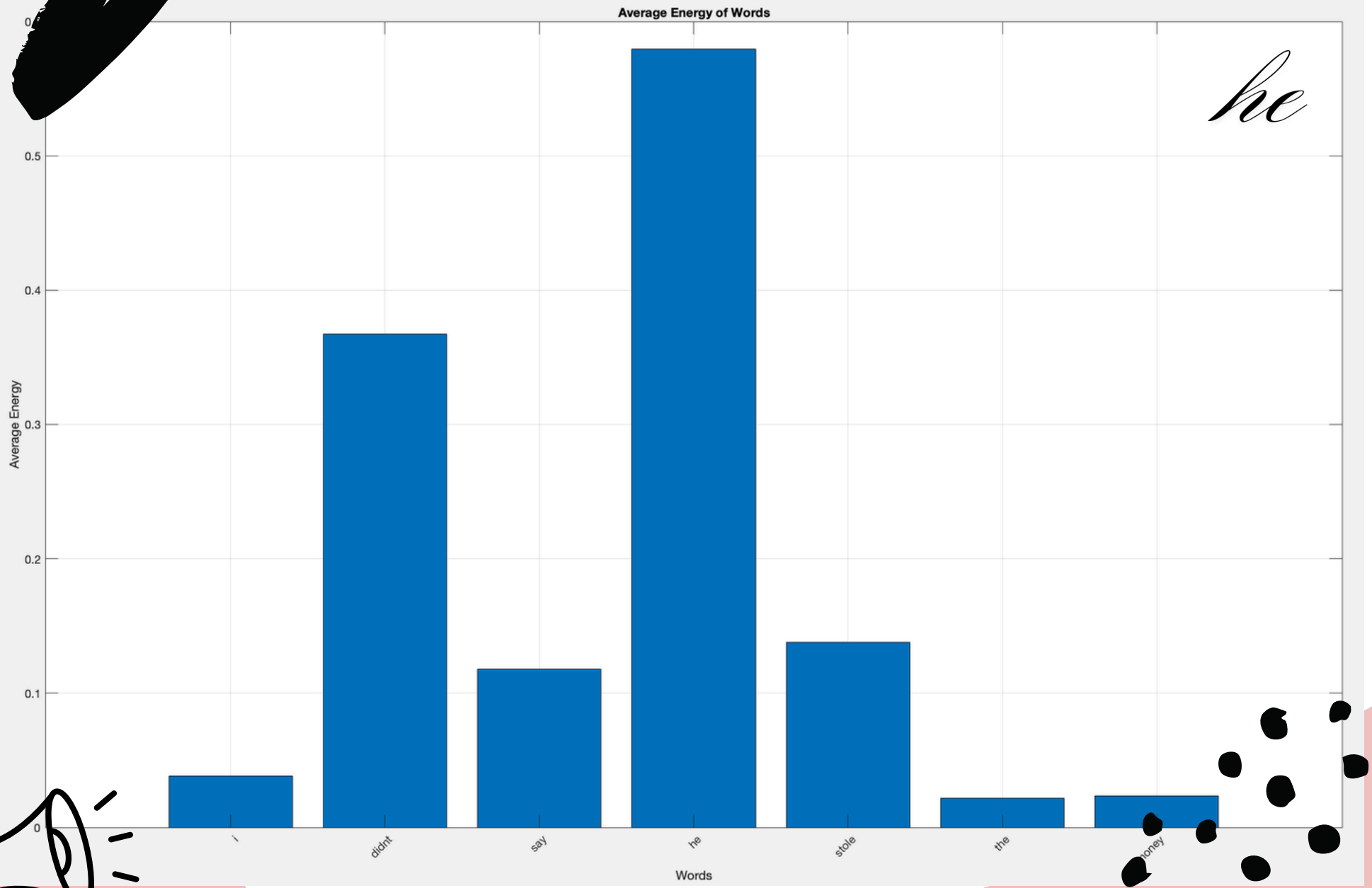
LOUDER WORDS FOR SIGNAL-5



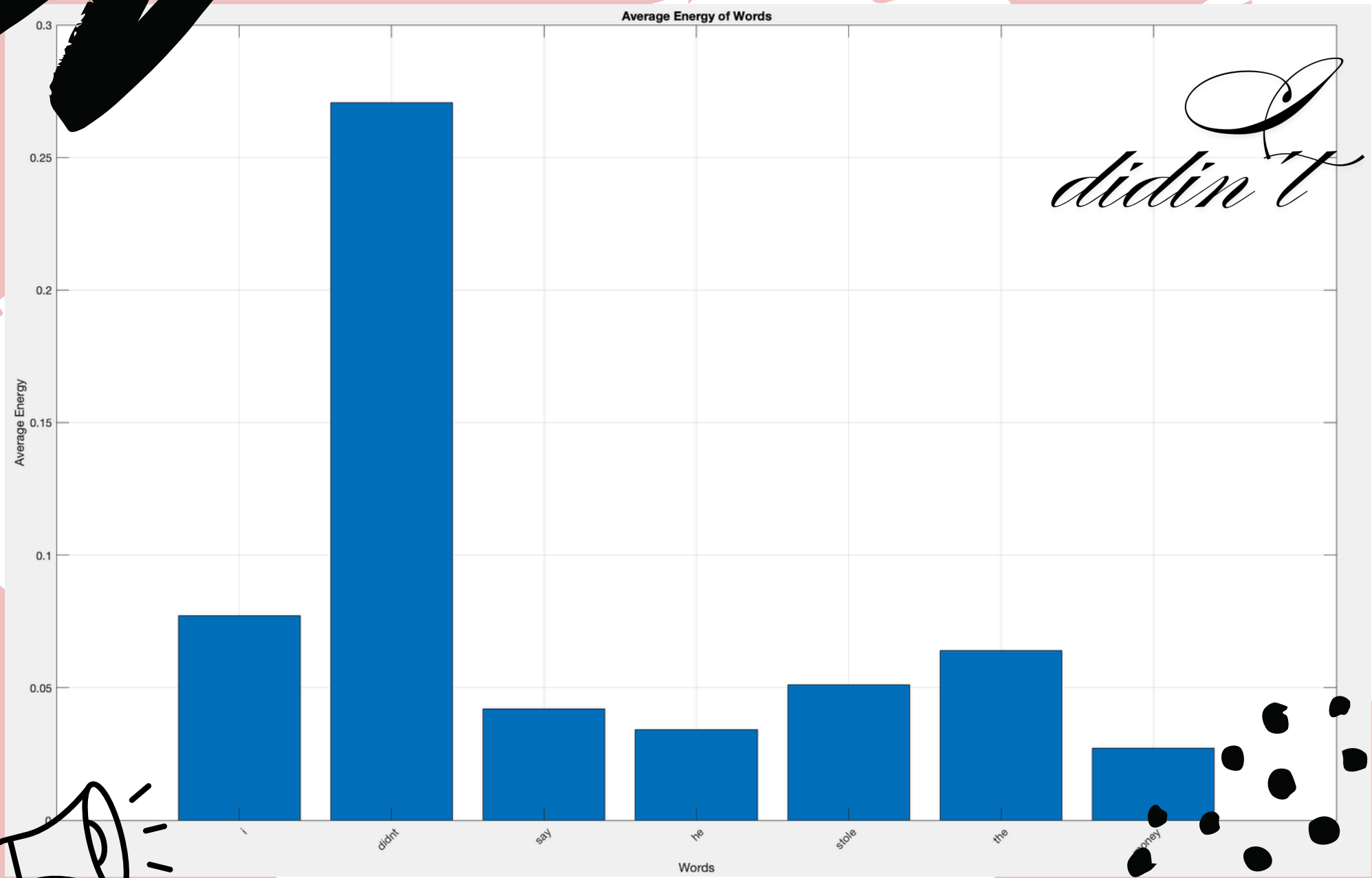
LOUDER WORDS FOR SIGNAL-6



LOUDER WORDS FOR SIGNAL-7

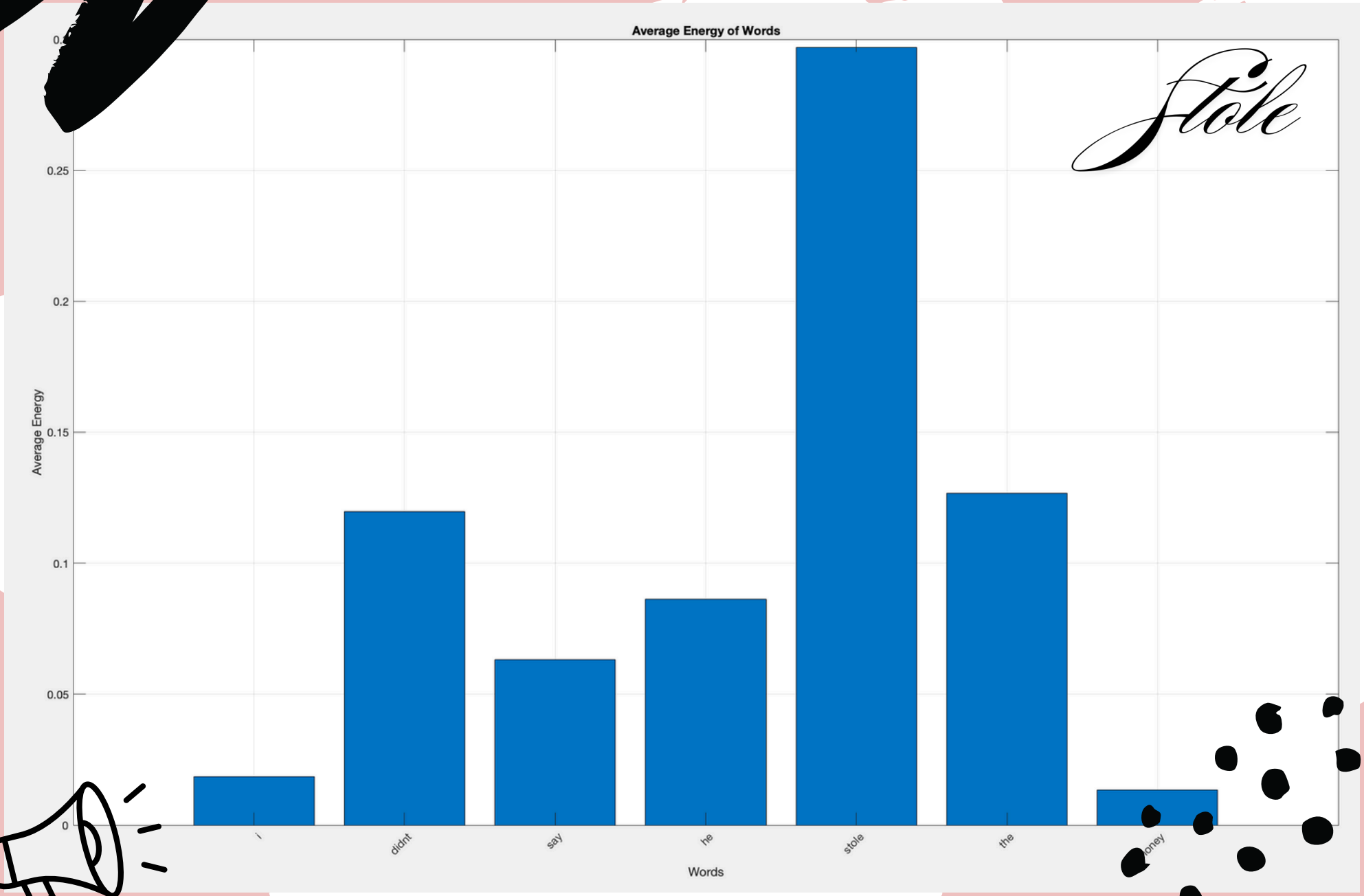


LOUDER WORDS FOR SIGNAL-8



didn't

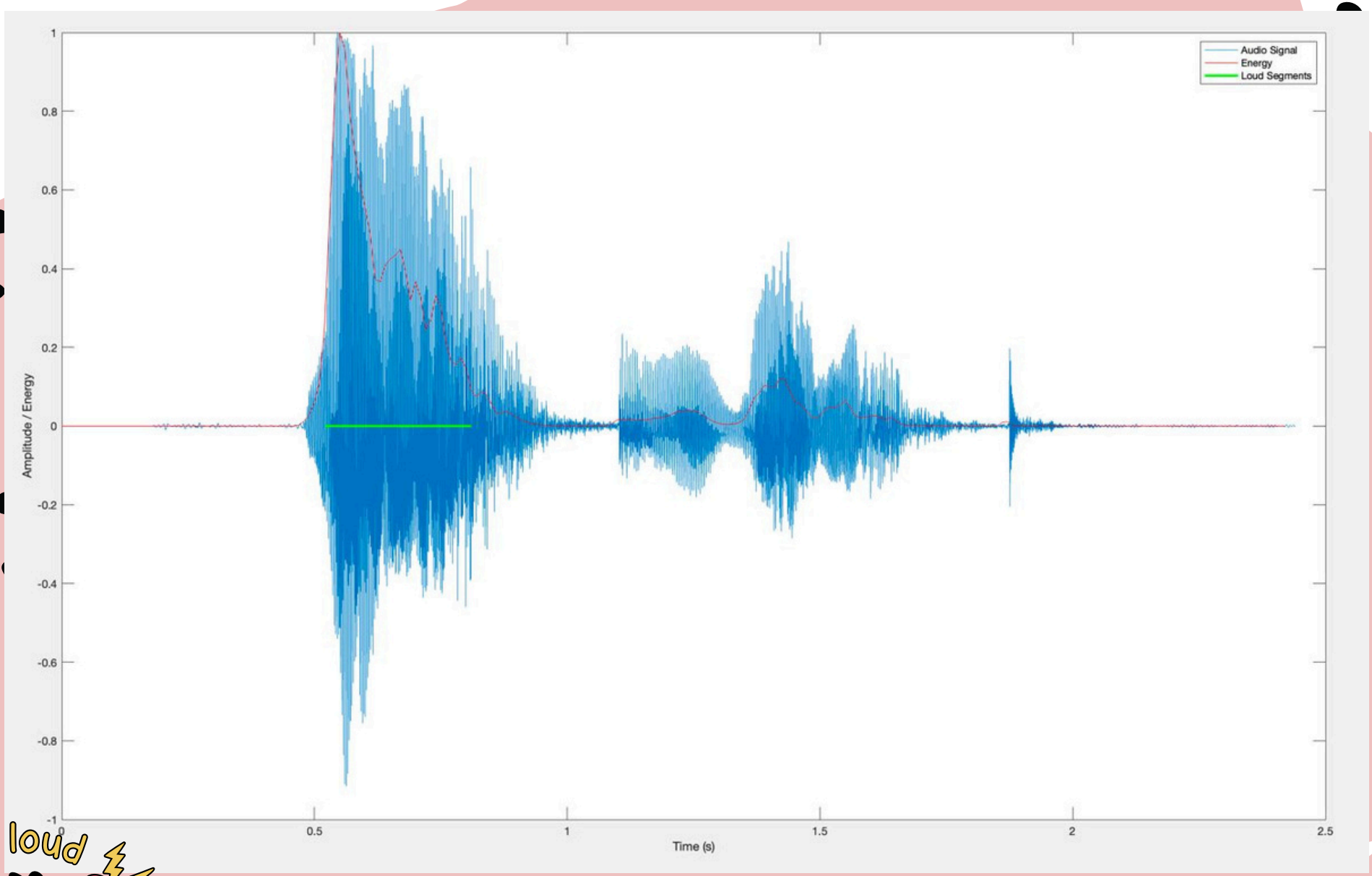
LOUDER WORDS FOR SIGNAL-9



PART - 2
{ANALYSIS}

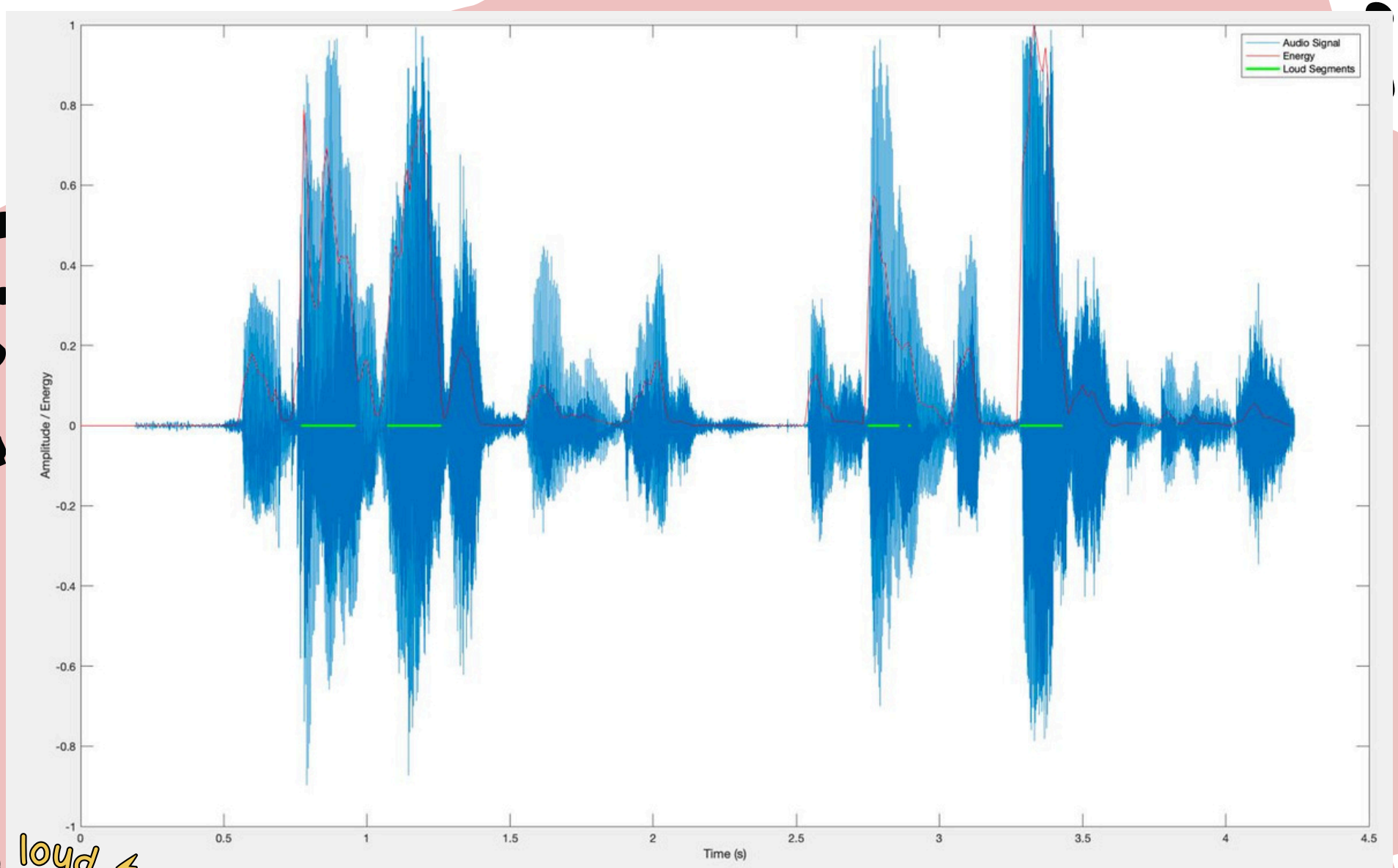
IN TASK 2, WE DETECT LOUDER SEGMENTS OF SPEECH BY ANALYZING THE AUDIO SIGNAL'S ENERGY IN OVERLAPPING FRAMES. ENERGY IS CALCULATED FOR EACH FRAME, AND A THRESHOLD IS SET USING THE MEAN AND STANDARD DEVIATION TO IDENTIFY LOUD FRAMES. CONSECUTIVE LOUD FRAMES ARE GROUPED TO FORM SEGMENTS, AND THEIR START AND END TIMES ARE COMPUTED. THIS METHOD ALLOWS LOUDNESS DETECTION WITHOUT PRE-SPECIFIED WORD BOUNDARIES.

SIGNAL 1



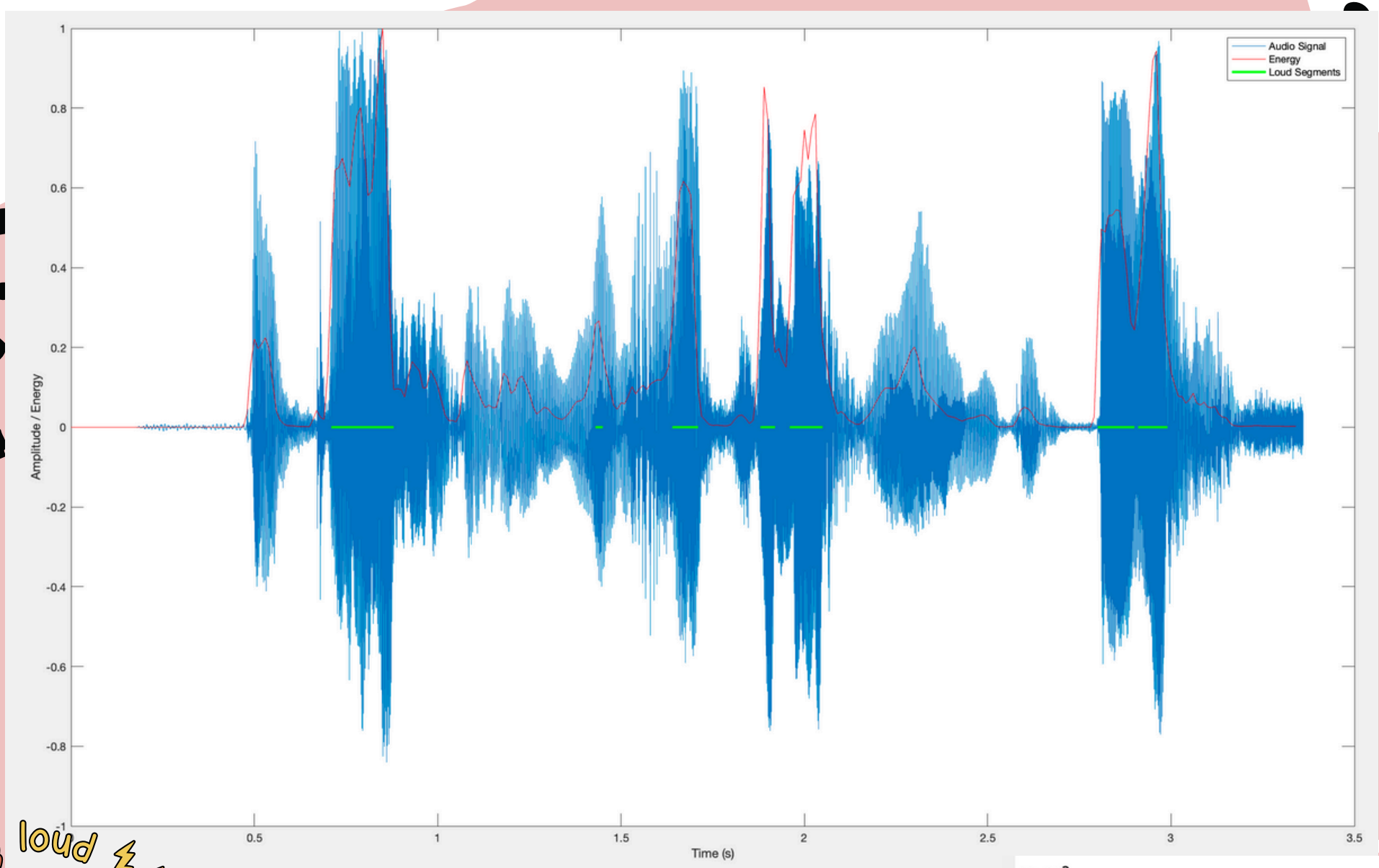

```
>> sp2
Louder segments (start and end times in seconds):
    0.5200    0.8100
```

SIGNAL 2



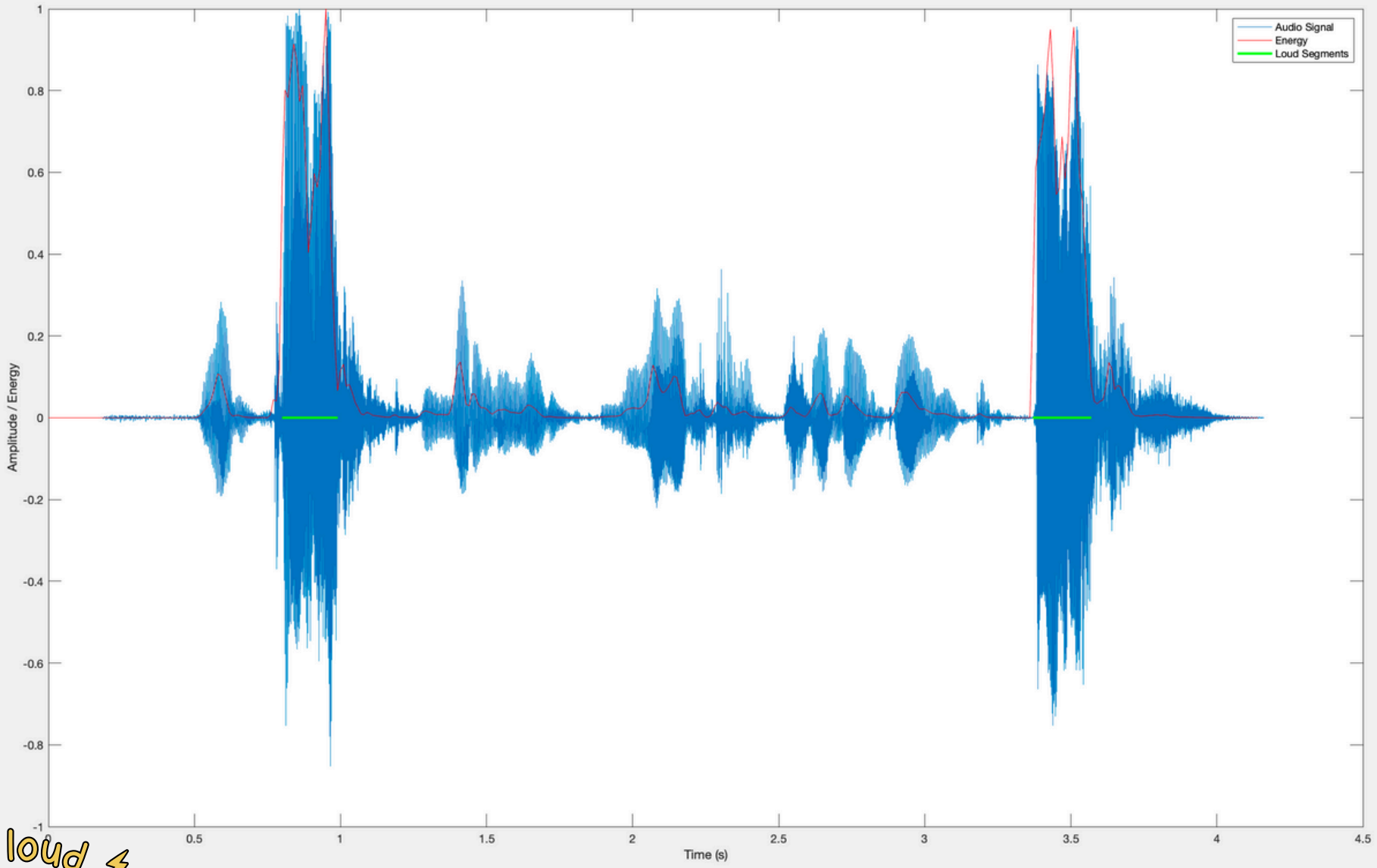

```
>> sp2
Louder segments (start and end times in seconds):
    0.7700    0.9600
    1.0700    1.2600
    2.7500    2.8600
    2.8900    2.9000
    3.2800    3.4300
```

SIGNAL 3



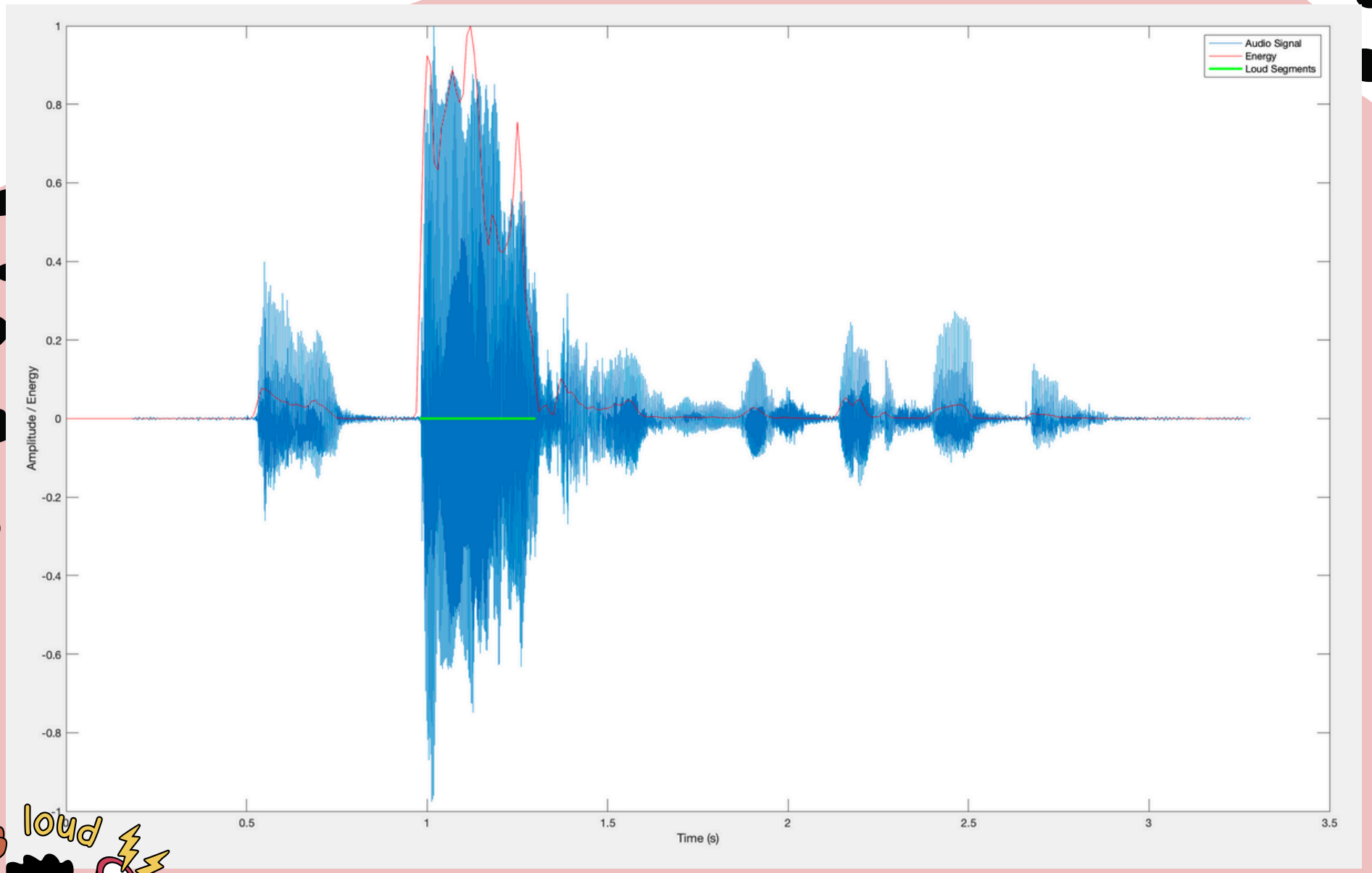

```
>> sp2
Louder segments (start and end times in seconds):
    0.7100    0.8800
    1.4300    1.4500
    1.6400    1.7100
    1.8800    1.9200
    1.9600    2.0500
    2.8000    2.9000
    2.9100    2.9900
```

SIGNAL 4



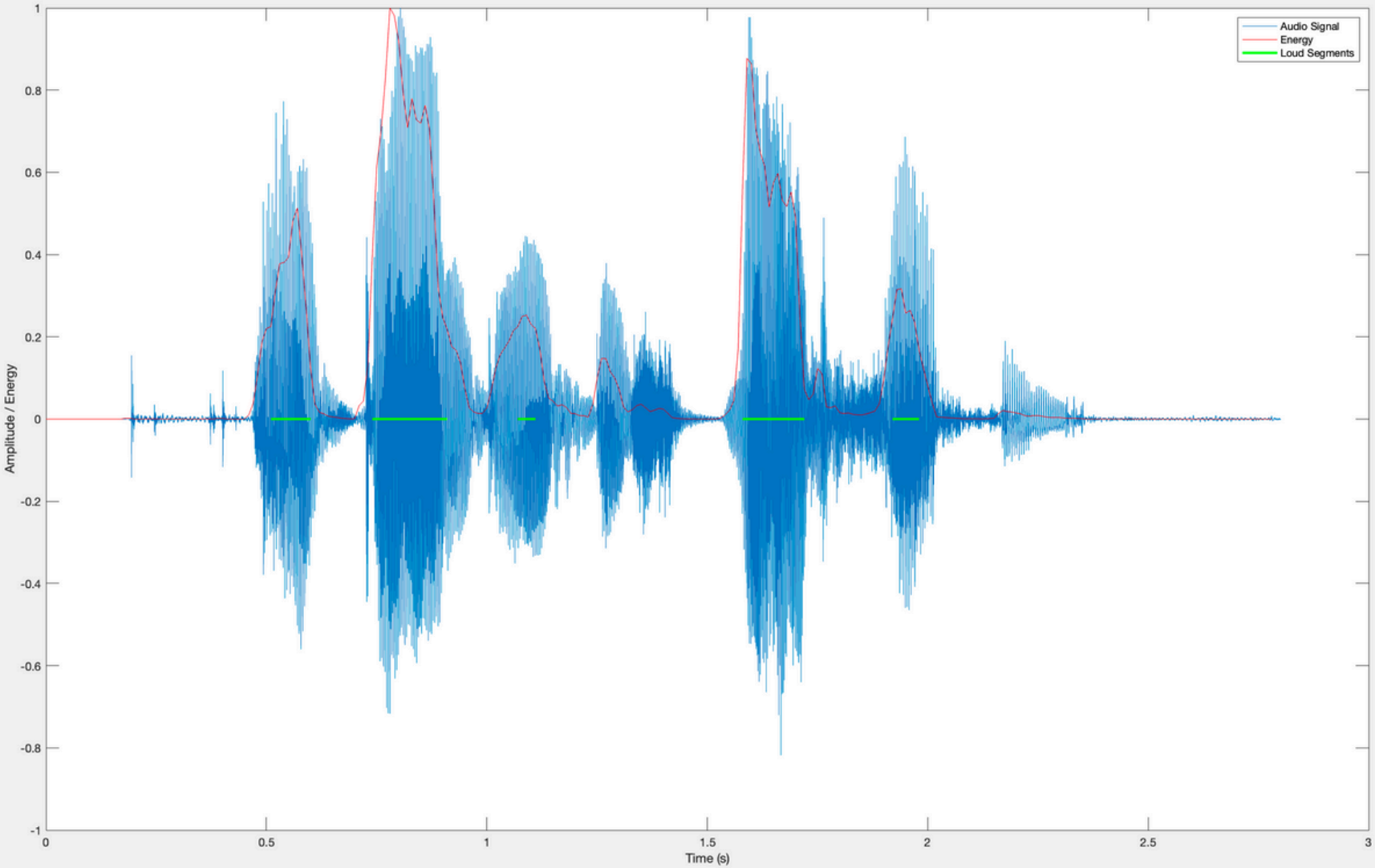

```
>> sp2
Louder segments (start and end times in seconds):
    0.8000    0.9900
    3.3700    3.5700
```

SIGNAL 5



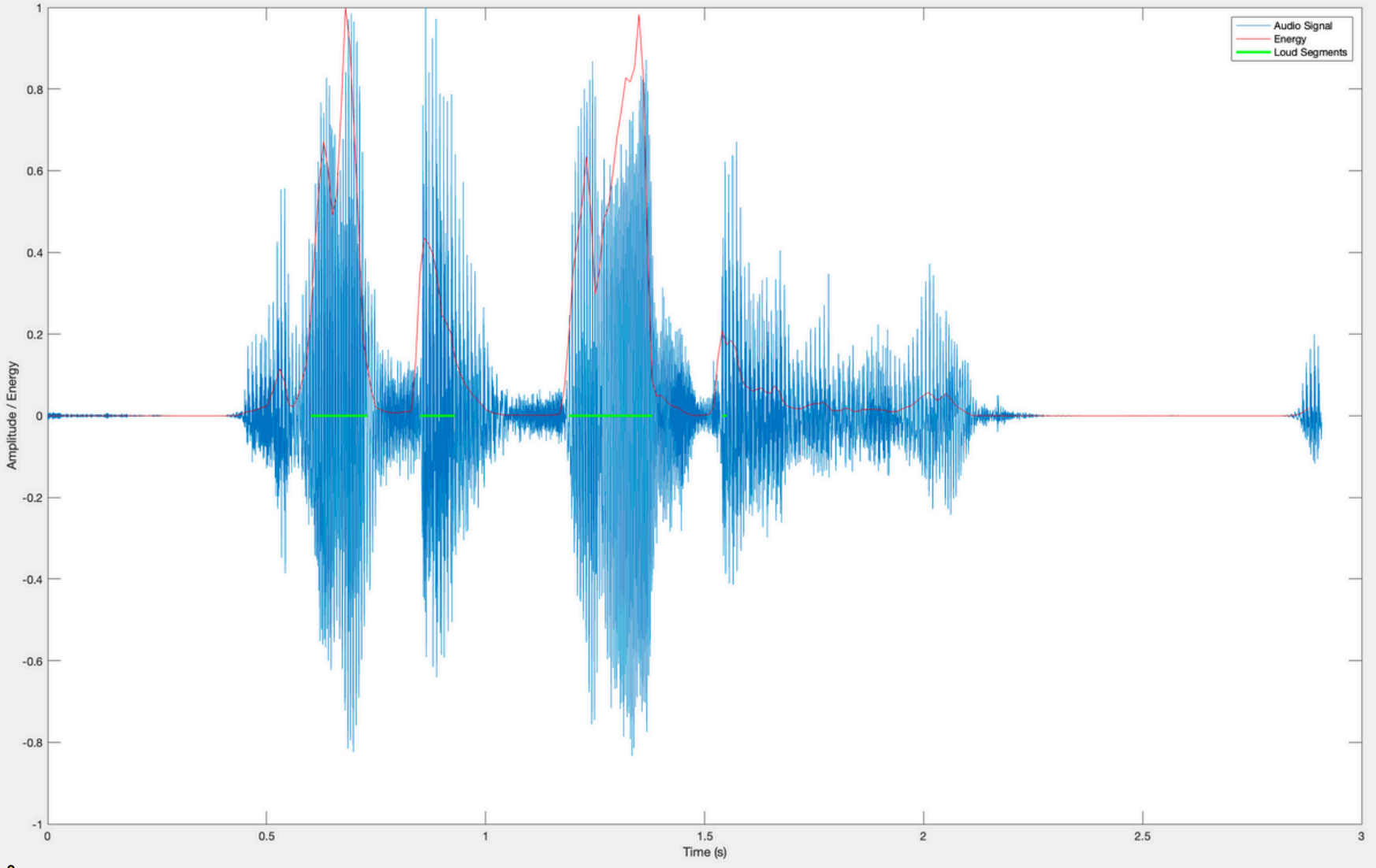

```
>> sp2
Louder segments (start and end times in seconds):
    0.9800    1.3000
```

SIGNAL 6



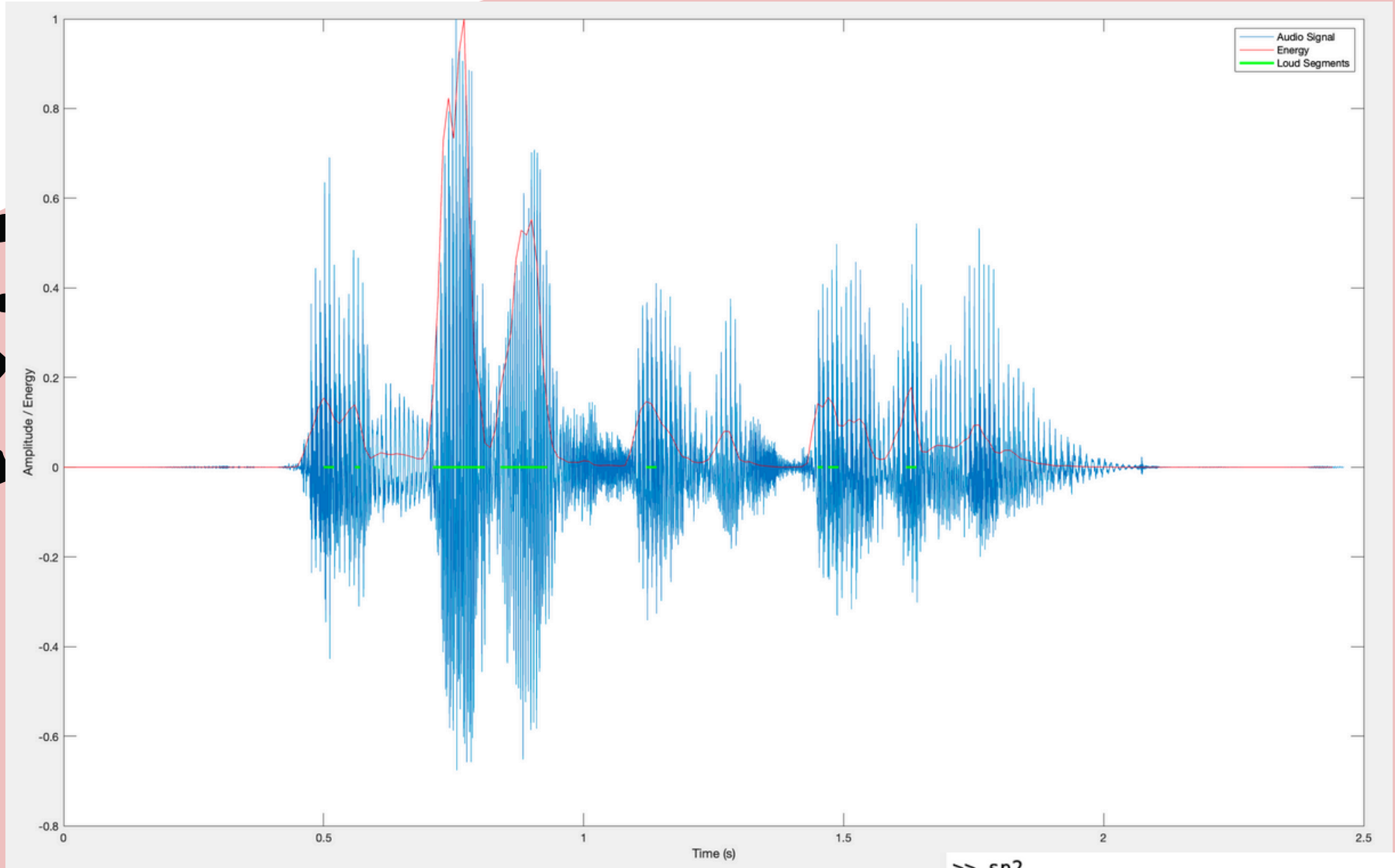

```
>> sp2
Louder segments (start and end times in seconds):
    0.5100    0.6000
    0.7400    0.9100
    1.0700    1.1100
    1.5800    1.7200
    1.9200    1.9800
```

SIGNAL 7



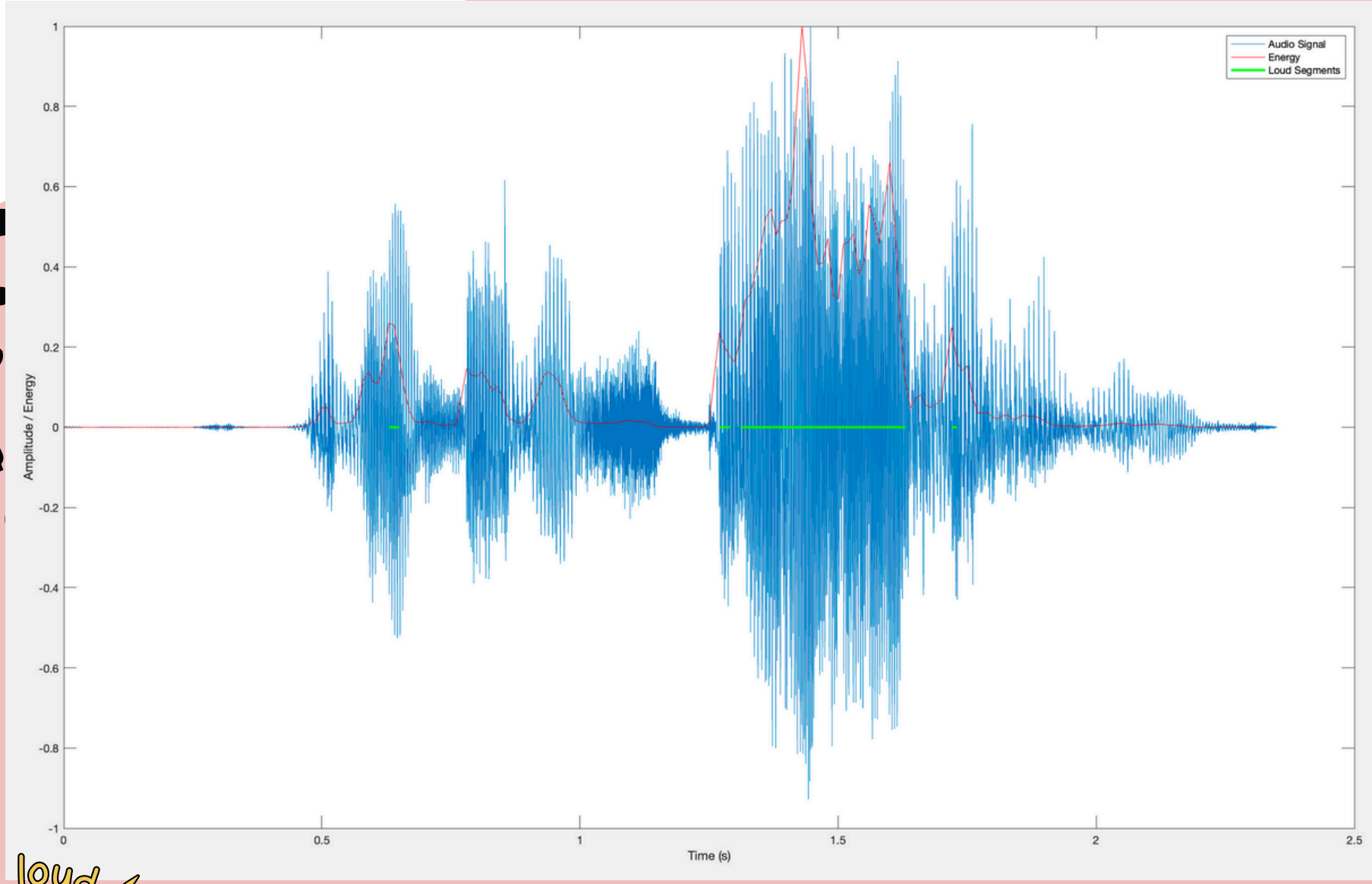

```
>> sp2
Louder segments (start and end times in seconds):
    0.6000    0.7300
    0.8500    0.9300
    1.1900    1.3800
    1.5400    1.5500
```

SIGNAL 8




```
>> sp2
Louder segments (start and end times in seconds):
    0.5000    0.5200
    0.5600    0.5700
    0.7100    0.8100
    0.8400    0.9300
    1.1200    1.1400
    1.4500    1.4600
    1.4700    1.4900
    1.6200    1.6400
```

SIGNAL 9




```
>> sp2
Louder segments (start and end times in seconds):
    0.6300    0.6500
    1.2700    1.2900
    1.3100    1.6300
    1.7200    1.7300
```

THANK YOU!!