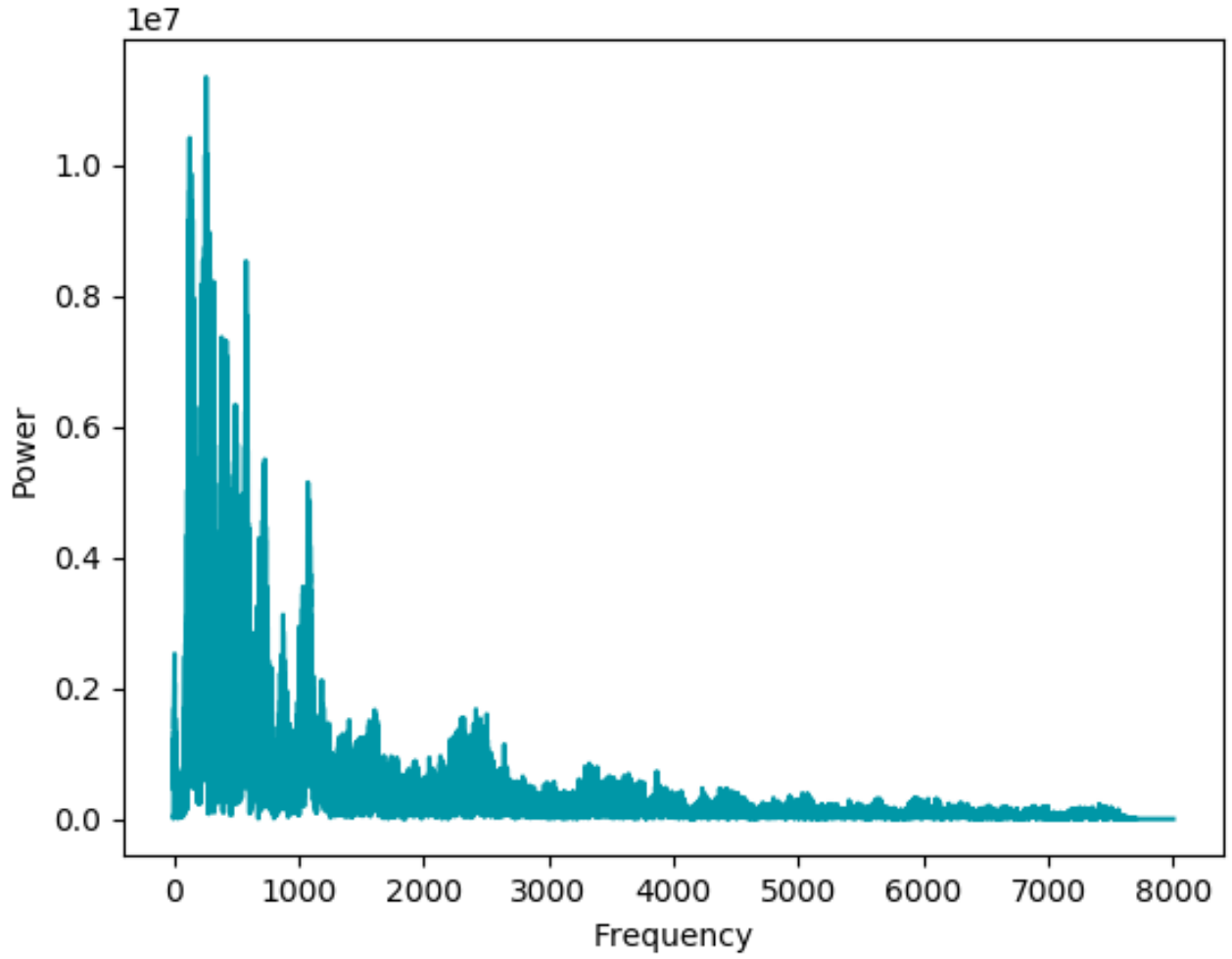
بخش اول

۱.

Spectral Analysis

Spectral analysis is one of several statistical techniques necessary for characterizing and analyzing sequenced data. Sequenced data are observations that have been taken in one, two, or three dimensional space, and/or time. Examples might be observations of population density along a road, or of rainfall over an area, or of daily births at a hospital. One important limitation is that the observations be equally spaced in order that the analysis proceed efficiently. Spectral analysis refers to the decomposition of a sequence into oscillations of different lengths or scales. By this process, the observations in what is called the data domain are converted into the spectral domain. The reasons for doing this are that: (a) some forms of manipulation are easier in the spectral domain; and (b) the revealed scales are necessary statistical descriptors of the data and may suggest important factors that affect or produce such data. The following will provide brief descriptions of: (a) Fourier analysis and its use in manipulating data that are assumed to be periodic; (b) relevant statistics; and (c) one approach to spectral analysis of nonperiodic data including an example.

۲. با استفاده از تابع fft در کتابخانه scipy نمودار power spectrum را رسم نمودیم. همچنین برای استخراج درست داده مجبور به تبدیل فرمت فایل ها از MP3 به WAV شدیم تا فشرده سازی خاصی روی داده انجام نشود.



۴. ابتدا با تابعی که در قسمت قبلی نوشتیم Spectrum value را بدست آورده سپس اگر مقدار حداکثر فرکانس از حدی که در پروژه تعریف شده، یعنی ۱۸۰هرتز بیشتر شد آن صدا را به عنوان صدای زن برچسب میزنیم، درغیر اینصورت به عنوان صدای مرد. نتیجه خروجی به ازای هر ورودی به شکل زیر است:

```
v0.wav: women, [213.2]
v1.wav: men, [114.7]
v10.wav: women, [227.1]
v11.wav: men, [121.3]
v2.wav: men, [95.5]
v3.wav: men, [148.]
v4.wav: women, [255.7]
v5.wav: women, [205.1]
v6.wav: men, [91.1]
v7.wav: women, [216.7]
v8.wav: men, [153.6]
v9.wav: women, [388.2]
```

برای اینکه حجم فایل ها زیاد است فقط ۱۰ ثانیه از آن را Sample میکنیم.

همچنین باید مقادیر اضافه را حذف کنیم. که مربوط به بخش دوم پروژه است.

بخش دوم

۱.

Spectral subtraction

Spectral subtraction is a method for restoration of the power or the magnitude spectrum of a signal observed in additive noise, through subtraction of an estimate of the average noise spectrum from the noisy signal spectrum. The noise spectrum is estimated, and updated, from the periods when the signal is absent and only the noise is present. The assumption is that the noise is a stationary or a slowly varying process, and that the noise spectrum does not change significantly in-between the update periods. For restoration of time-domain signals, an estimate of the instantaneous magnitude spectrum is combined with the phase of the noisy signal, and then transformed via an inverse discrete Fourier transform to the time domain. In terms of computational complexity spectral subtraction is relatively inexpensive. However, due to random variations of noise, spectral subtraction can result in negative estimates of the short-time magnitude or power spectrum. The magnitude and power spectrum are non-negative variables, and any negative estimate of these variables should be mapped into a non-negative value. This nonlinear rectification process distorts the distribution of the restored signal. The processing distortion becomes more noticeable as the signal to noise ratio decreases. In this chapter we study spectral subtraction, and the different methods of reducing and removing the processing distortions.

۲. از روش Spectral Over Subtraction استفاده میکنیم. الگوریتم به شرح زیر است:

```
1.Short-time Fourier transform of noisy input signal
2.get magnitude
3.get phase
4.We need phase info for inverse transform in last step
5.Short-time Fourier transform of noise only signal
6.subtract noise spectral mean from input spectral, and Inverse Short-Time
  Fourier Transform
7.reshape for broadcast to subtract
8.apply phase information
9.back to time domain signal
```

The spectral subtractive-type algorithm is the family of different variants of the spectral subtraction method such as spectral over-subtraction, multi-band spectral subtraction, Wiener filtering, iterative spectral subtraction, and spectral subtraction based on perceptual properties. Thus, the principle of the spectral subtractive-type algorithms is to estimate the short-time spectral magnitude of the speech by subtracting estimated noise from the noisy speech spectrum or by multiplying the noisy spectrum with gain functions and to combine it with the phase of the noisy speech.

A. Spectral over-subtraction

In this algorithm[9], two additional parameters are introduced in the spectral subtraction method[8]: over-subtraction factor, and noise spectral floor to reduce the remnant noise. The algorithm is given as

$$|\widehat{S}(\omega)|^2 = \begin{cases} |Y(\omega)|^2 - \alpha|\widehat{D}(\omega)|^2, & \text{if } |Y(\omega)|^2 > (\alpha+\beta)|\widehat{D}(\omega)|^2 \\ \beta|\widehat{D}(\omega)|^2 & \text{else} \end{cases} \tag{10}$$

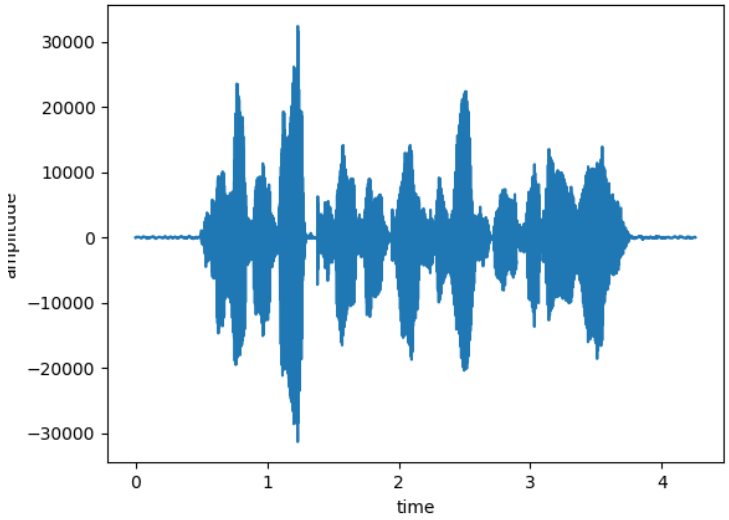
with $\alpha \geq 1$ and $0 \leq \beta \ll 1$.

The over-subtraction factor controls the amount of noise power spectrum subtracted from the noisy speech power spectrum in each frame and spectral floor parameter prevent the resultant spectrum from going below a preset minimum level rather than setting to zero (spectral floor). The over-subtraction factor depends on a-*posteriori* segmental SNR (SSNR). The over-subtraction factor can be calculated as

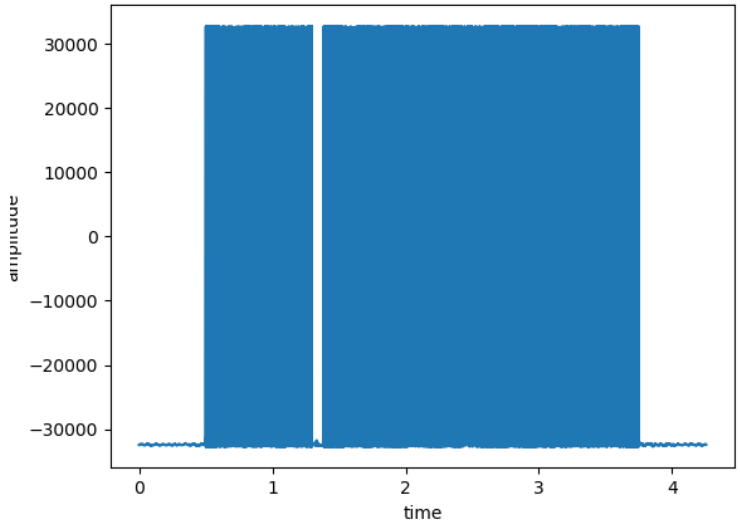
$$\alpha = 4 - \frac{3}{20}\,\text{SSNR}, \quad \text{if } -5 \leq \text{SSNR} \leq 20 \tag{11}$$

۳.

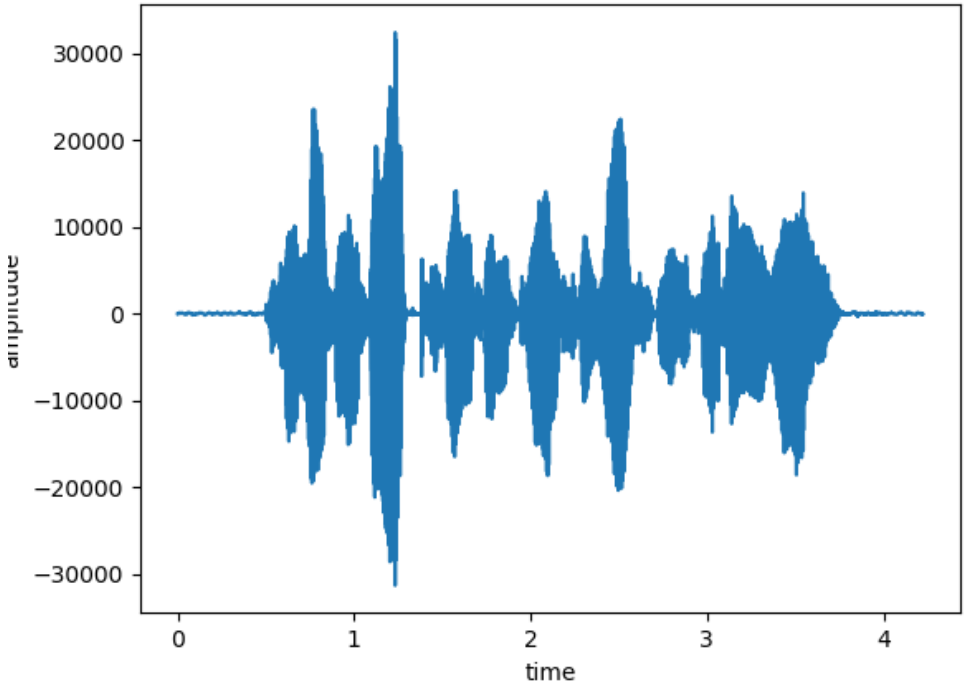
ورودی اصلی:



بعد از اعمال نویز:



بعد از اجرای الگوریتم حذف نویز Spectral Subtraction:



همانطور که مشاهده می شود و درفایل پیوستیfixed.wav قرار داده شده است. نتیجه فرق خاصی با اصل فایل ندارد.

این موضوع قدرت الگوریتم به کار گرفته شده را به نمایش میگذارد.