

Pitch Detector

ISPR - Midterm 1
Assignment 3

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Autocorrelogram

- The autocorrelogram Auto_y measures the correlation of a signal y with itself at different time lags:

$$\text{Auto}_y[\tau] = \frac{1}{\|y\|^2} \sum_{t=0}^{N-\tau-1} y[t] \cdot y[t + \tau].$$

- It can be computed by convolution, but for a small set of time lags (window), the naive implementation is more efficient.

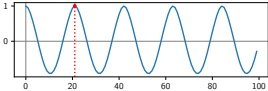
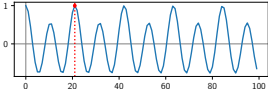
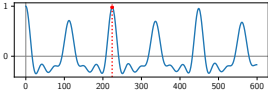
```
def autocorrelogram(y, window):  
    b, e = window  
    a = np.array([np.dot(y[0 : y.size - tau], y[tau :])  
                  for tau in range(b, e)])  
    return a / a[0]
```

Finding the Pitch

- ▶ Peaks in the autocorrelogram correspond to periods of the signal **y**.
- ▶ The minimal period τ_0 of **y** is the smallest maximum point of the autocorrelogram **after 0**.

```
def find_pitch(y, sr, lowest_freq = 80.):  
    cor = autocorrelogram(y, [0, int(sr / lowest_freq)])  
    peaks = []  
    for a in np.split(np.arange(cor.size),  
                      np.nonzero(cor < 0)[0].tolist())[1 :]:  
        u = [i for i in a if cor[i] > .01]  
        if u:  
            peaks.append(max(u, key = lambda i: cor[i]))  
    highest_peak = max(cor[p] for p in peaks)  
    f = np.array([p for p in peaks  
                  if cor[p] > .95 * highest_peak])  
    d = np.average(f / np.arange(1, f.size + 1), 0, cor[f])  
    return sr / d
```

Results

Instrument	Note	Autocorrelogram	Pitch	Error
Clarinet	C6		1049 Hz	0.2 %
Oboe	C6		1046 Hz	0.01 %
Keyboard (homemade)	G3		196.7 Hz	0.3 %

Real-time Pitch Detection

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