Pitch Detector

ISPR - Midterm 1
Assignment 3

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Autocorrelogram

- The autocorrelogram $\text{Auto}_{\mathbf{y}}$ measures the correlation of a signal $\mathbf{y}$ with itself at different time lags:

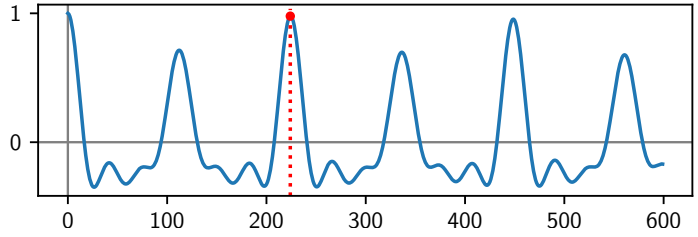
$$\text{Auto}_{\mathbf{y}}[\tau] = \frac{1}{\|\mathbf{y}\|^2} \sum_{t=0}^{N-\tau-1} \mathbf{y}[t] \cdot \mathbf{y}[t+\tau].$$

- 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]
```

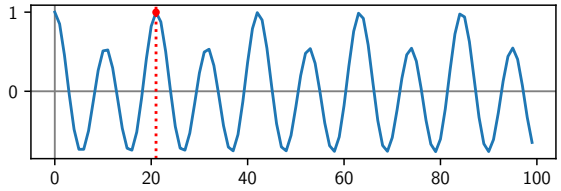
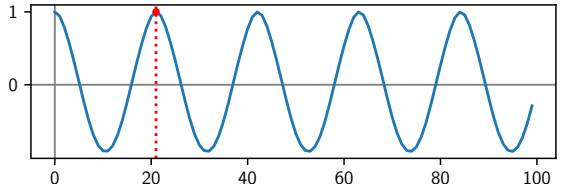
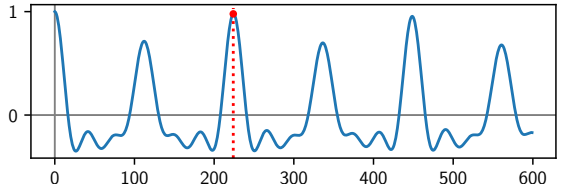
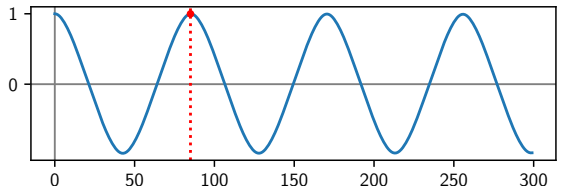
Finding the Pitch

- 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
Oboe	C6		1046 Hz	0.01 %
Clarinet	C6		1049 Hz	0.2 %
Keyboard (homemade)	G3		196.7 Hz	0.3 %
Voice (homemade)	D3		145.1 Hz	1 %

Real-time Pitch Detection

- This algorithm is fast enough to run in real-time.
- `pyaudio` for microphone input, `pyglet` for graphics.
- And now, a live demonstration!