Pitch Detector

ISPR - Midterm 1
Assignment 3

Filippo Baroni

March 30, 2021

Autocorrelogram

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

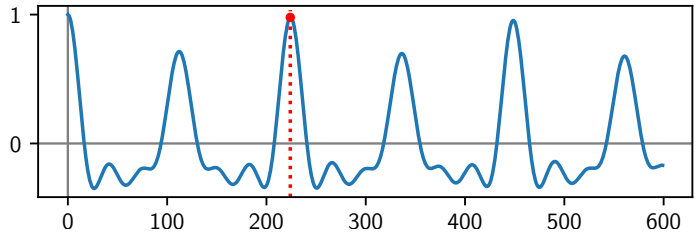
$$\text{Auto}_{\mathbf{y}}[\tau] = \frac{1}{\|\mathbf{y}\|^2} \sum_{t=0}^{N-\tau-1} \mathbf{y}[t] \cdot \mathbf{y}[t+\tau].$$

- It can be computed as the convolution between $\mathbf{y}$ and reverse($\mathbf{y}$).

```
def autocorrelogram(y):
    a = np.convolve(y, y[: : -1], 'same')
    a = a[a.size // 2 :]
    return a / np.dot(y, y)
```

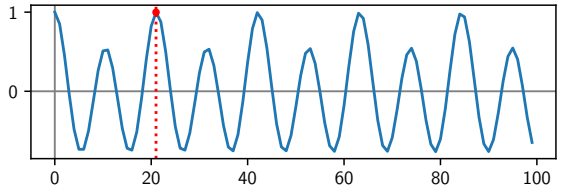
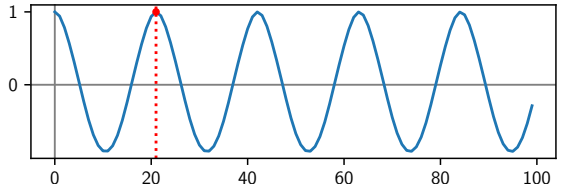
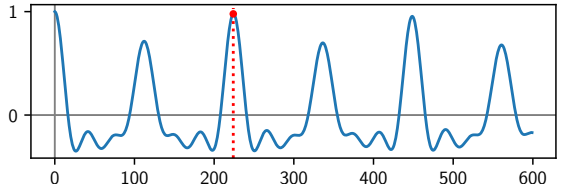
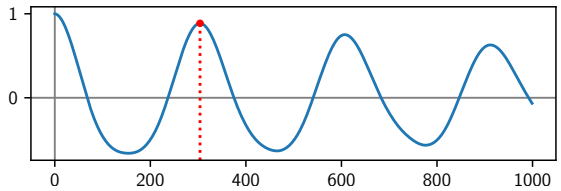
Finding the Pitch

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




```
def find_pitch(y, sr):
    a = autocorrelogram(y)
    peaks = np.array([], dtype = int)
    for b in np.split(np.arange(a.size),
        np.nonzero(a < 0)[0])[1 :]:
            if np.any(a[b] > .01):
                peaks.append(b[np.argmax(a[b])])
    highest_peak = max(a[peaks])
    f = peaks[a[peaks] > .95 * highest_peak][: 10]
    tau = np.average(f / np.arange(1, f.size + 1), 0, a[f])
    return sr / tau
```

Results

Instrument	Note	Autocorrelogram	Pitch	Error
Oboe	C6		1046 Hz	0.03 %
Clarinet	C6		1049 Hz	0.3 %
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!