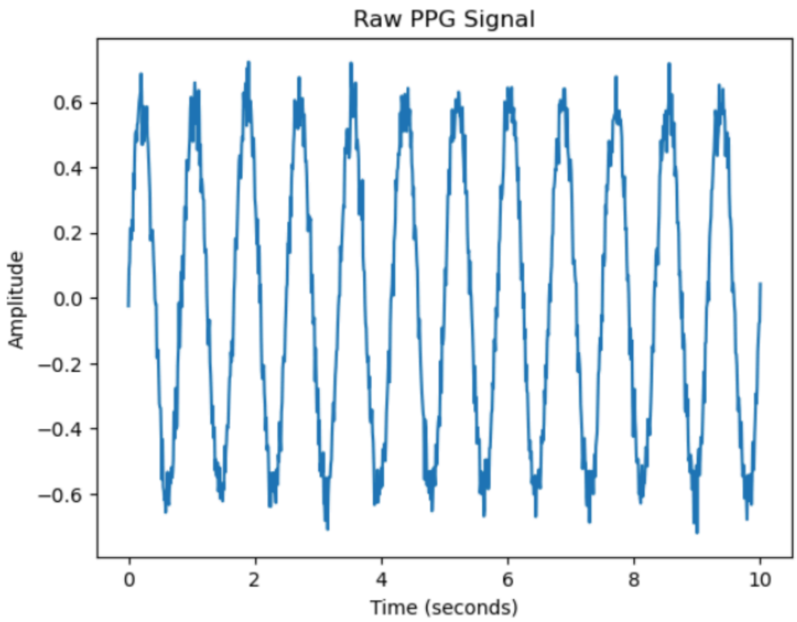
Feature Extraction of a PPG Signal

Title:
Feature Extraction from Photoplethysmography (PPG) Signals for Physiological Monitoring

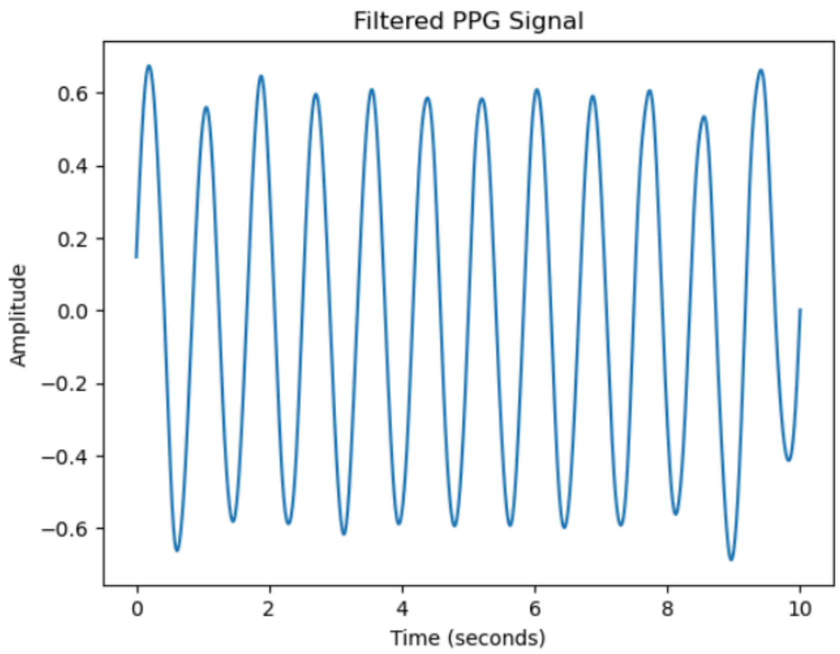
Theory:
Photoplethysmography (PPG) is an optical measurement technique that detects changes in blood volume in the microvascular bed of tissue. It is commonly used to monitor heart rate, blood oxygen levels, and other vital signs. PPG signals are generated by emitting light into the skin and measuring the amount of light absorbed by blood vessels as they expand and contract with the cardiac cycle. These signals can be processed and analyzed to extract meaningful features that provide insights into a person's cardiovascular health.

Feature extraction is the process of identifying key characteristics of a signal that can be used to interpret or classify the underlying physiological conditions. In the case of PPG signals, features can be divided into three categories:
1.Time-domain features describe the signal's behavior over time, such as the average heart rate or amplitude of the signal.
2.Frequency-domain features are obtained by analyzing the signal's frequency components, revealing information about the dominant rhythms (e.g., heart rate) and variations in frequency.
3.Nonlinear features capture the complexity and unpredictability of the signal, which can indicate abnormal physiological conditions arrhythmias.
By extracting these features, PPG signals can be used for health monitoring, early detection of cardiovascular diseases, and other applications in wearable health technology.

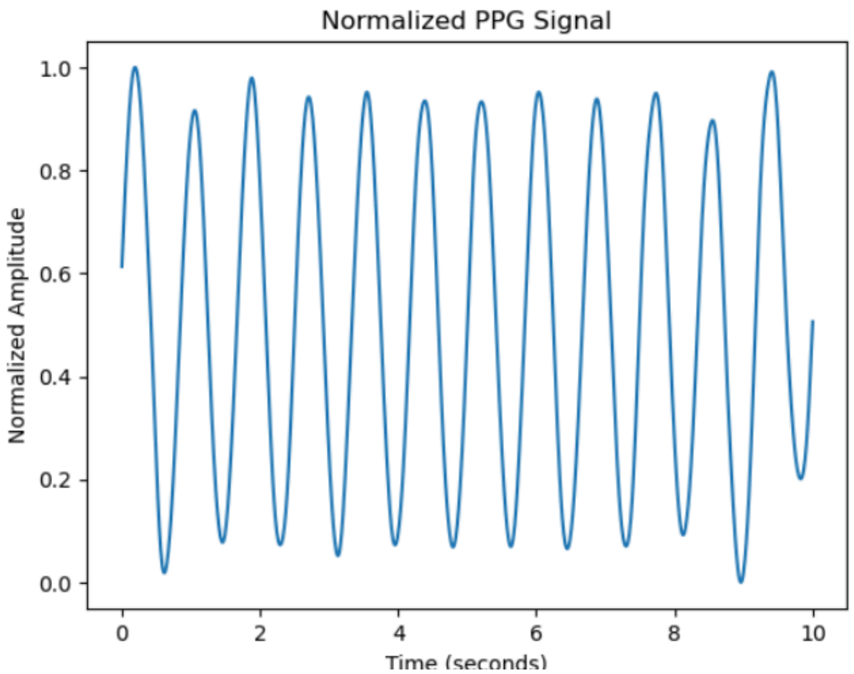
code
```
import numpy as np
import matplotlib.pyplot as plt

# Simulating a PPG signal (replace with actual data)
fs = 100  # Sampling rate (Hz)
t = np.linspace(0, 10, fs * 10)  # 10 seconds of data
ppg_signal = 0.6 * np.sin(2 * np.pi * 1.2 * t) + np.random.normal(0, 0.05, len(t))

# Plotting the raw PPG signal
plt.plot(t, ppg_signal)
plt.title("Raw PPG Signal")
plt.xlabel("Time (seconds)")
plt.ylabel("Amplitude")
plt.show()
```




```
from scipy.signal import butter, filtfilt

# Bandpass filter design (0.5 to 5 Hz for heart rate detection)
def bandpass_filter(signal, lowcut, highcut, fs, order=4):
    nyquist = 0.5 * fs
    low = lowcut / nyquist
    high = highcut / nyquist
    b, a = butter(order, [low, high], btype='band')
    return filtfilt(b, a, signal)

# Filtered PPG signal
filtered_ppg = bandpass_filter(ppg_signal, 0.5, 5, fs)
plt.plot(t, filtered_ppg)
plt.title("Filtered PPG Signal")
plt.xlabel("Time (seconds)")
plt.ylabel("Amplitude")
plt.show()
```

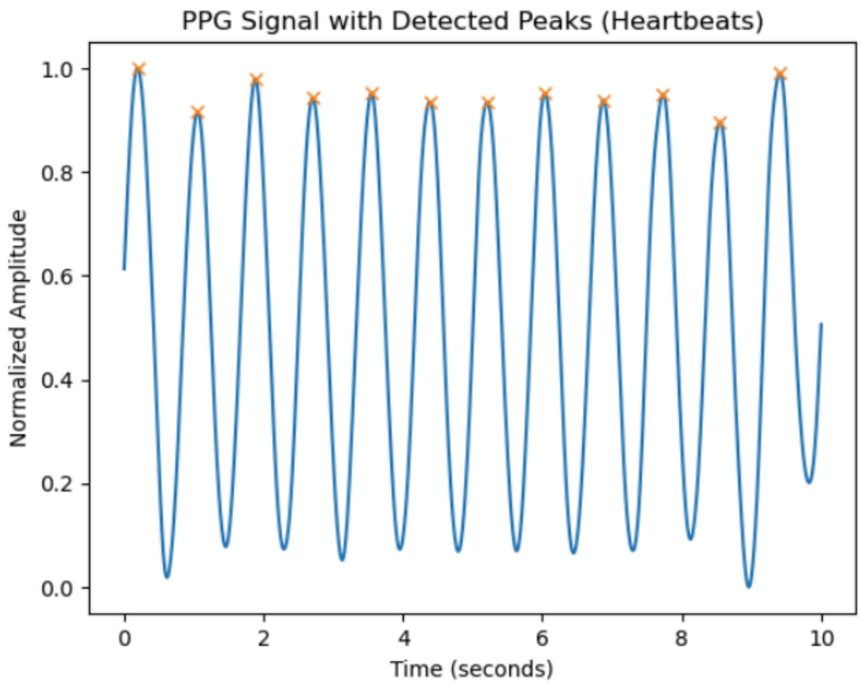



```
normalized_ppg = (filtered_ppg - np.min(filtered_ppg)) / (np.max(filtered_ppg) - np.min(filtered_ppg))
plt.plot(t, normalized_ppg)
plt.title("Normalized PPG Signal")
plt.xlabel("Time (seconds)")
plt.ylabel("Normalized Amplitude")
plt.show()
```




```
from scipy.signal import find_peaks
```

```
# Detect peaks in the PPG signal
peaks, _ = find_peaks(normalized_ppg, distance=fs*0.6)  # Minimum distance of 0.6
seconds between peaks (for HR < 100 BPM)

# Calculate Heart Rate (BPM)
ibi = np.diff(peaks) / fs  # Inter-beat interval in seconds
heart_rate = 60 / ibi  # Convert to beats per minute (BPM)

# Plot the PPG signal with detected peaks
plt.plot(t, normalized_ppg)
plt.plot(t[peaks], normalized_ppg[peaks], "x")
plt.title("PPG Signal with Detected Peaks (Heartbeats)")
plt.xlabel("Time (seconds)")
plt.ylabel("Normalized Amplitude")
plt.show()

print("Heart Rate: ", np.mean(heart_rate), " BPM")
```




```
Heart Rate:  71.68175833415685  BPM
```

```
#Oxygen Saturation (SpO2) Calculation
# Assume red and infrared PPG signals (simulated)
red_ppg = 0.7 * np.sin(2 * np.pi * 1.2 * t) + np.random.normal(0, 0.05, len(t))
infrared_ppg = 0.6 * np.sin(2 * np.pi * 1.2 * t) + np.random.normal(0, 0.05, len(t))

# SpO2 estimation (simplified version)
ratio = np.mean(red_ppg) / np.mean(infrared_ppg)
SpO2 = 110 - 25 * ratio  # Formula depends on device calibration

print("Estimated SpO2: ", SpO2, "%")
```

```
import matplotlib.pyplot as plt

# Simulated heart rate and SpO2 data
time = np.arange(0, len(heart_rate))  # Time index for heart rate
SpO2_values = np.random.normal(95, 1, len(time))  # Simulated SpO2 values

# Plotting heart rate and SpO2
plt.subplot(2, 1, 1)
plt.plot(time, heart_rate, label='Heart Rate (BPM)')
plt.ylabel('BPM')
plt.title('Heart Rate and SpO2 Over Time')

plt.subplot(2, 1, 2)
plt.plot(time, SpO2_values, label='SpO2 (%)', color='red')
plt.ylabel('SpO2 (%)')
plt.xlabel('Time (seconds)')

plt.show()
```