BME 544 Assignment 2

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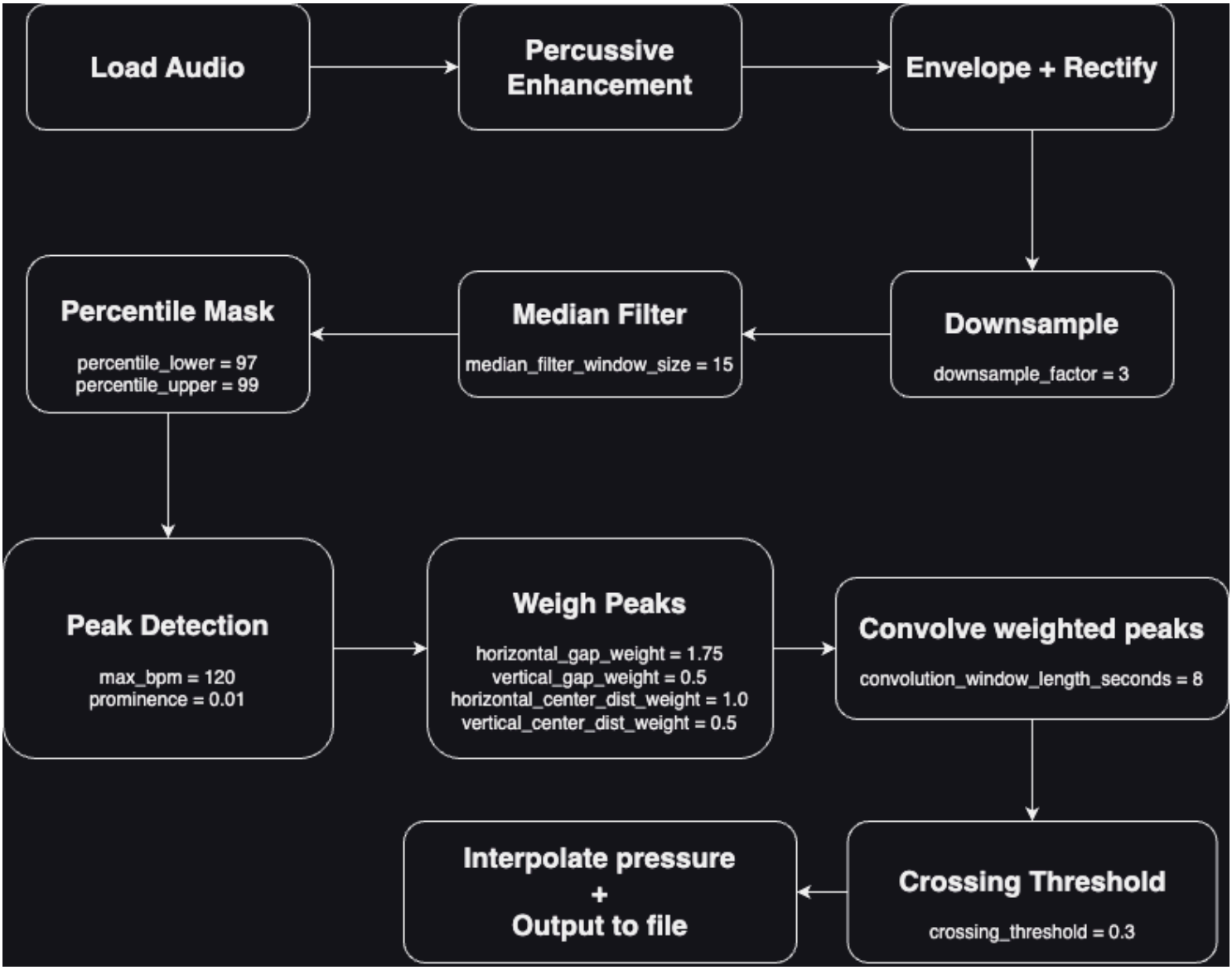
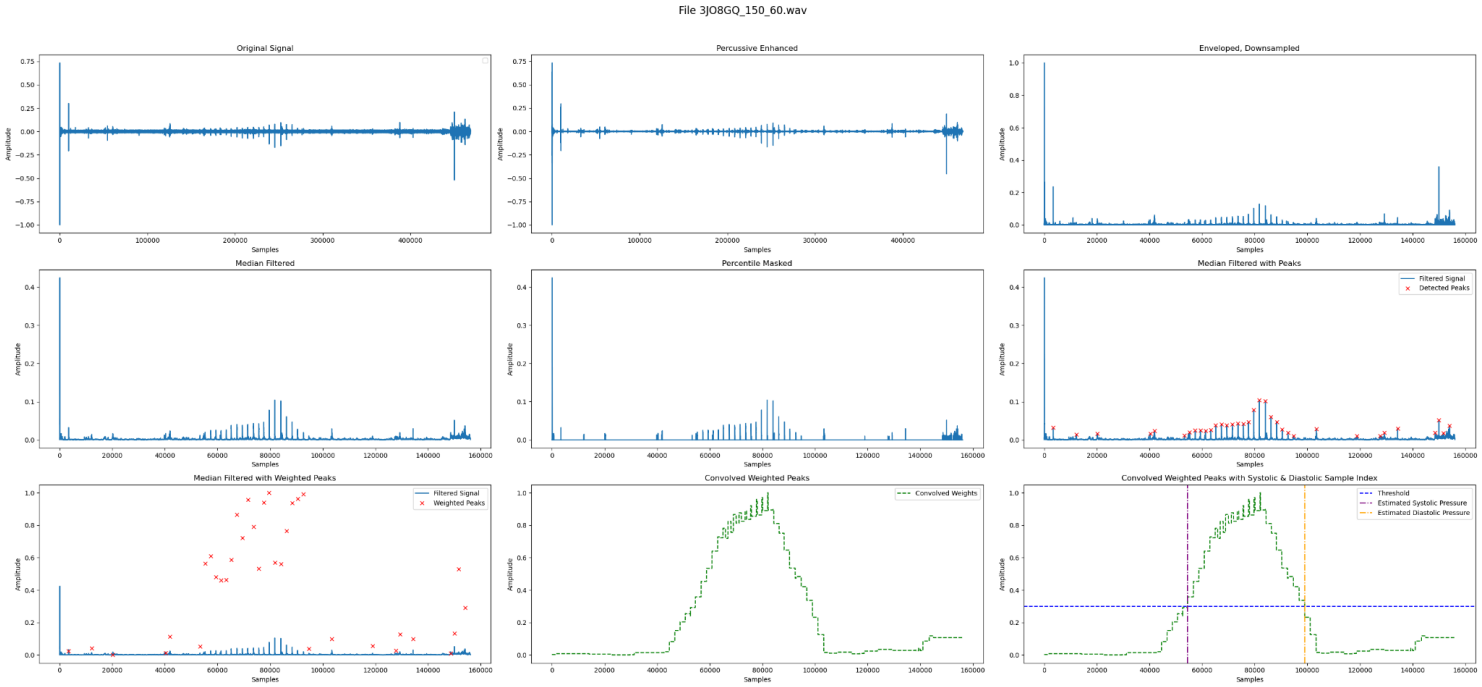
Algorithm Overview

Firstly the algorithm loops through all the .wav files to load the audio data and the sample rate. Initially, a built-in function to enhance percussive sounds is used to enhance the Korotkoff sounds. Next, a rectified envelope of the signal is found to simplify further computation. Next, the signal is downsampled to sharpen the peaks of the Korotkoff sounds and to dull peaks of steady state noise. Next, a rolling median filter is used to dull steady state noise and enhance Korotkoff sound peaks. Next, an upper and lower percentile mask is used to eliminate any loud transient noise peaks and soft steady state noise peaks. Peak detection is then executed on the masked signal. Each detected peak is then weighed accordingly in attempts to weigh the signal peaks more than non-signal peaks. After normalizing the weights of the peaks, remaining non-peak sample indexes are filled with zeros and a convolution is performed on this intermediate signal. Lastly, the output of the convolution is then used as a probability density function for whether or not the current sample index contains a Korotkoff sound. A threshold is applied to the bounds of the probability density function to find the sample indices corresponding to the systolic and diastolic pressures as the start and end of the Korotkoff sound. The start and end pressure values are then used to interpolate and estimate the systolic and diastolic pressures assuming a linear decrease in pressure. In the end, each estimate is saved to a csv file, Assignment_2_output.csv.

Flow Chart


Load Audio
Percussive Enhancement
Envelope + Rectify
Downsample
downsample_factor = 3
Median Filter
median_filter_window_size = 15
Percentile Mask
percentile_lower = 97
percentile_upper = 99
Peak Detection
max_bpm = 120
prominence = 0.01
Weigh Peaks
horizontal_gap_weight = 1.75
vertical_gap_weight = 0.5
horizontal_center_dist_weight = 1.0
vertical_center_dist_weight = 0.5
Convolve weighted peaks
convolution_window_length_seconds = 8
Crossing Threshold
crossing_threshold = 0.3
Interpolate pressure
+
Output to file

Example


File 3JO8GQ_150_60.wav
Original Signal
Percussive Enhanced
Enveloped, Downsampled
Median Filtered
Percentile Masked
Median Filtered with Peaks
Filtered Signal
Detected Peaks
Median Filtered with Weighted Peaks
Filtered Signal
Weighted Peaks
Convolved Weighted Peaks
Convolved Weights
Convolved Weighted Peaks with Systolic & Diastolic Sample Index
Threshold
Estimated Systolic Pressure
Estimated Diastolic Pressure
Amplitude
Samples

Parameters

Downsampling

downsample_factor: This parameter was chosen to be **3** as a way to sharpen the peaks from the Korotkoff sounds. Increasing this parameter may dull peaks as a result of potential removal of the sharpest peak. Decreasing this parameter may not achieve the intended purpose of removing non-maximal values from peaks.

Median Filtering

median_filter_window_size: This parameter was chosen to be **15** as a balance between reducing noise but not dulling peaks

Percentile Mask

percentile_lower: This parameter was chosen to be **97** to filter out enough steady-state noise peaks without filtering out signal peaks
percentile_upper: This parameter was chosen to be **99** to filter out transient-noise peaks without filtering out signal peaks

Peak Detection

max_bpm: This parameter was chosen based on a buffered value of the nominal healthy adult heart rate of 60-100 bpm [1]. This value was buffered to **120** bpm to ensure that any deviation from nominal is still able to be captured, while not allowing the buffer to be too large to detect non-signal peaks.

Weighing Peaks

horizontal_gap_weight*: The value of this parameter was chosen to be **1.75** to ensure an appropriate prioritization of weighing peaks based on each peaks' horizontal gap to its neighbors and how close it is to the nominal (median) horizontal gap. This appropriately weighs more signal peaks than non-signal peaks, as signal peaks tend to have a regular interval.
vertical_gap_weight*: The value of this parameter was chosen to be **0.5** to ensure an appropriate prioritization of weighing peaks based on each peaks' vertical gap to its neighbors and how close it is to the nominal (median) vertical gap. This appropriately weighs more signal peaks than transient noise peaks, as signal peaks theoretically have a slower rate of change which would theoretically result in the peaks' gap being closer to the nominal vertical gap.
horizontal_center_dist_weight*: The value of this parameter was chosen to be **1.0** to ensure an appropriate prioritization of weighing signal peaks based on the contiguous nature of the Korotkoff sounds. This allows for small groups of peaks in the horizontal axis far away from the nominal (median) peak to be weighed less, as they are more likely to be noise. The larger group of Korotkoff sound peaks, which are closer to the nominal peak, would therefore be weighed more
vertical_center_dist_weight*: The value of this parameter was chosen to **0.5** to ensure an appropriate prioritization of weighing signal peaks more than loud transient noise peaks or small steady state noise peaks, as those noise peaks would likely be farther away from the vertical nominal peak compared to signal peaks.
*The absolute values of the parameters in this step are irrelevant, since there are multiple normalization steps in between.

Convolve Weighted Peaks

convolution_window_length_seconds: This parameter was chosen to be 5 seconds as a good balance between an output that doesn't have too much high frequency content, while ensuring that Korotkoff sound envelope features are still prominent compared to noise.

Crossing Threshold

crossing_threshold: This parameter was chosen to be 0.3 as a good balance between an overestimate and underestimate of the systolic pressure - diastolic pressure gap.