Errata

J. Pan and W. J. Tompkins, A real-time QRS detection algorithm. *IEEE Trans. Biomed. Eng.*, **BME-32**(3):230-236, 1985.

This article includes several errors, particularly in equations for the high-pass filter and the derivative.

Low-pass filter

The group delay of the filter was stated incorrectly to be six samples. It is actually five samples (corresponding to 25 ms at the 200 sps sampling rate).

High-pass filter

The high-pass filter is implemented by subtracting a low-pass filter from an all-pass filter. The low-pass filter is an integer-coefficient filter having the transfer function:

$$H_{lp}(z) = \frac{1 - z^{-32}}{1 - z^{-1}} \tag{2.1}$$

This low-pass filter has a *dc* gain of 32 and a group delay 15.5 samples (i.e., 77.5 ms). To produce the high-pass filter, the output of the low-pass filter is divided by its *dc* gain and subtracted from the original signal. Before subtraction, the original signal is delayed by 16*T* $\left(\text{i.e., } z^{-16}\right)$ to compensate for the low-pass filter's group delay.

The transfer function of the high-pass filter is derived from:

$$H_{hp}(z) = z^{-16} - \frac{H_{lp}(z)}{32} \tag{2.2}$$

Substituting Eq. (2.1) into (2.2) and solving for $H_{hp}(z)$, the transfer function for the high-pass filter is:

$$H_{hp}(z) = \frac{-\frac{1}{32} + z^{-16} - z^{-17} + \frac{z^{-32}}{32}}{1 - z^{-1}} \tag{2.3}$$

This filter may be implemented with the difference equation:

$$y(nT) = y(nT - T) - \frac{x(nT)}{32} + x(nT - 16T) - x(nT - 17T) + \frac{x(nT - 32T)}{32} \tag{2.4}$$

The low cutoff frequency is about 5 Hz, and the gain is one. The equation for the amplitude response is much more complicated than the one given in the article. This filter has a group delay of about 16*T* (80 ms).

Derivative

The derivative is a 5-point derivative with the transfer function:

$$H(z) = \frac{1}{10}\left(-2z^{-2} - z^{-1} + z^{1} + 2z^{2}\right) \tag{2.5}$$

The derivative is implemented with the difference equation:

$$y(nT) = \frac{1}{8}\left[2x(nT) + x(nT - T) - x(nT - 3T) - 2x(nT - 4T)\right] \tag{2.6}$$

The fraction of 1/8 is a reasonable approximation of the actual gain factor of 1/10 to permit fast power-of-two division. This derivative approximates an ideal derivative between dc and 30 Hz. The derivative has a group delay of 2*T* (10 ms).

Squaring function

The output of the squaring function is hard-limited to a maximal value of 255.