HIGH-SPEED ALGORITHM FOR PLETHYSMOGRAPH PEAK DETECTION IN REAL-TIME APPLICATIONS

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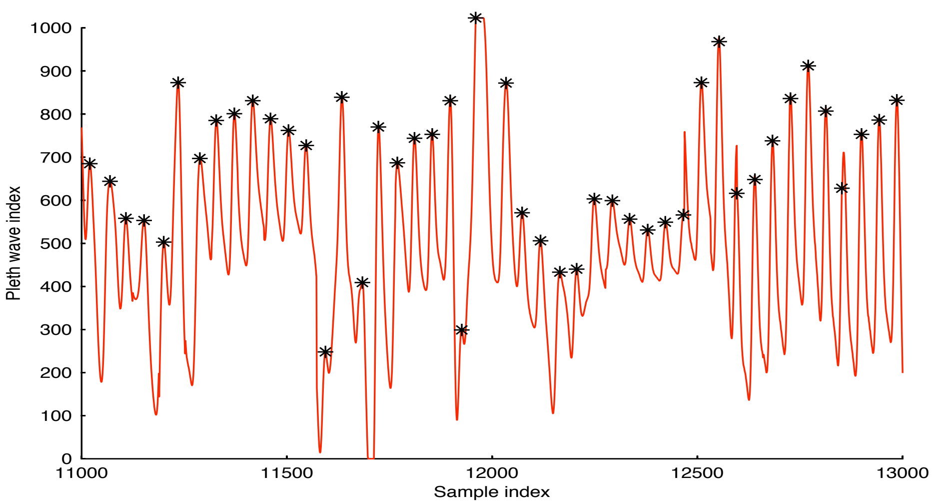
Introduction: Conventional methods for peak detection involve complicated filter banks and/or frequency domain analysis. We present a much simpler and computationally efficient method using an iterative function fractal. The simple nature of such functions and their ability to operate on complex unfiltered data could potentially provide a useful trade-off between speed and complexity for real-time applications in systems with limited resources, such as mobile phones.

Method: We considered a one-dimensional iterative function fractal $f_n = \{ (P_n - P_{n-1} > 0 \ ?\ 1 : 0) + f_{n-1} \} / 2$ with peak detection logic $f_n<0.6$ ^ $f_{n-1}>0.999$, P_n being the unfiltered plethysmogram data. This algorithm was implemented in a few lines of C language and applied to two publicly available expert annotated plethysmogram benchmark data sets with a total of >15,000 annotated peaks and a sampling rate of 125Hz [1]. No tuning was performed against the benchmark data, and no checks applied to validate the calculated peak positions. Only the $f_{n-1}>0.999$ threshold has significance to the detection and was selected independently by processing 75Hz plethysmogram data collected with a Nonin™ Xpod™ oximeter module.

Results: The algorithm displayed good resistance to changes in signal offset and amplitude, as shown in figure 1(a). Statistical analysis against the benchmark data further revealed a positive predictive median value of 98.8% (98.6-99.8%) and a sensitivity of median 97.7% (97.3-98.1%) (figure 1(b)). The PPV is about 1% less than results achieved with a much more elaborate conventional algorithm [2], but does provide a clinically acceptable tradeoff between speed and accuracy. The algorithm is fully implemented by three lines of C code, and has virtually no computational overhead.

Conclusion: A fractal method to analyze plethysmographic signal waveforms has been developed, and we have shown good correlation with benchmark data. The method provides a new method for detecting the heart rate with extremely low computational requirements, ideal for embedded real time systems and mobile applications.



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SET 1		Expert	
		Positive	Negative
Algorithm	Positive	9450 (P)	182 (FP)
	Negative	17 (FN)	- (N)

Positive Predictive Value: 99.8 %
Sensitivity: 98.1 %

SET 2		Expert	
		Positive	Negative
Algorithm	Positive	6317 (P)	174 (FP)
	Negative	87 (FN)	- (N)

Positive Predictive Value: 98.6 %
Sensitivity: 97.3 %

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References

1. http://bsp.pdx.edu

2. M. Aboy, J McNames, T Thong, D Tsunami, MS Ellenby and B Goldstein, "An Automatic Beat Detection Algorithm for Pressure Signals", IEEE T-BME 52 1662 (2005)