APPLICATION OF WAVELETS AND FRACTALS TO DETECTION OF CARDIAC ANOMALIES

PROBLEM: Detection of irregular heartbeat (premature ventricular contraction (PVC)).

1. Can lead to arrhythmia and heart attacks.
2. PVC localized in time, yet its high frequencies are indistinguishable from normal heartbeats. How to find?

SOLUTION: Take Daubechies wavelet transform.

1. Fine scales can't distinguish PVC from normal.
2. Coarse scales CAN detect PVC from normal heartbeats.

PROBLEM: Stenosis (narrowing of arteries) from too much cholesterol, etc.→blockage.

IDEA: Stenosis→turbulence→heartSOUNDS.

1. Turbulence tends to be *fractal*: $\sigma^2_{x(at)} = a^{-2H}\sigma^2_{x(t)}$ where H=Hurst exponent; $(2-H)$=*fractal dimension*.

2. Wavelet xform $x_n^m = \int x(t)2^{m/2}\psi(2^m t - n)dt$.
   a. $x(t)$ fractal→ $\sigma^2_{x_n^m} = 2^{-(2H+1)m}\sigma^2$.
   b. Log-log plot of $\sigma^2_{x_n^m}$ vs. scale $m \rightarrow H$ from slope.

SOLUTION: Compute variance in n of x_n^m.

1. Assume detail signals x_n^m are stationary in n.
2. PVC→fractal→ $\sigma^2_{x_n^m} = 2^{-(2H+1)m}\sigma^2$.
3. $(2-H)$=fractal dimension=$\begin{cases} 1.45 & \text{for normal} \\ 1.95 & \text{for PVC} \end{cases}$

   Also, PVC→line on log-log plot; normal→no line

See over for plots; IEEE Spectrum May 1997 for details.