A Method for Accurate Determination of Respiratory Rate in Real-Time from Pulse Oximeter Data

This discovery uses the pulse oximeter signal to estimate a respiratory rate. It offers the promise of cost savings, increased patient comfort and expanded pulse-oximetry use in diagnosing and monitoring respiratory conditions where monitoring respiratory rate is important.

Background:

Pulse oximeters are simple, non-invasive instruments used extensively in hospitals and emergency rooms to acquire patient oxygen saturation and cardiac functions. To maximize the potential of pulse oximetry, researchers have explored additional measurements, including respiratory rates. Today, respiratory rates can only be determined with costly equipment and additional sensors that patients often find uncomfortable, which further limits its use as a diagnostic tool.

Evidence suggests that respiratory rates modulate the frequency and amplitude of photoplethysmography (PPG) signals, but the time-varying nature of the modulations, the subtlety of the modulations and the presence of noise and motion that masks the modulations make it impossible to derive a respiratory rate. The development of a method to accurately determine a respiratory rate in real-time from pulse oximeter data would offer the promise of cost-savings, increased patient comfort and expanded pulse-oximetry use in diagnosing and monitoring respiratory conditions where monitoring respiratory rate is important.

Technology Description:

Ki Chon, Ph.D., professor in the Department of Biomedical Engineering at Stony Brook University, has developed a new method that uses the pulse oximeter signal to estimate a respiratory rate. He developed an algorithm called “variable frequency complex demodulation” (VFCD) to identify frequency modulations of the photoplethysmogram waveform. The algorithm is based on the highest possible time and frequency resolution method for estimating time-frequency spectra (TFS) and associated amplitudes. VFCD provides the best time and frequency resolution and most accurate amplitude estimates compared to continuous wavelet transform (CWT), power-spectral density, autoregressive modeling (AR) and other time frequency based methods for determining respiratory rate.

Advantages

- Accurately detects a wide range of respiratory rates from raw PPG signals.
- Most accurate and repeatable results when compared to AR, CWT-FM and CWT-AM methods (lowest median errors and variance values).
- Detects modulations in AM or FM signals.
- Considerably faster than CWT methods; real-time applications considerably faster and easier.

Applications

- Determining respiratory rates using pulse oximetry
- Sleep apnea detection
- Detection of hypervolemia or hypovolemia conditions
- Sudden infant death syndrome

Time-frequency analysis via VFCDM method on the pulse oximeter signal. The subject was instructed to breath at 0.2 Hz. Note the oscillation at the heart rate peak of 1 Hz.

Patents / Publications:

- Patent Pending
- A high resolution approach to estimating time-frequency spectra and their amplitudes.
  
- Estimation of respiratory rate from photoplethysmaogram data using time-frequency spectral Estimation.
  

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