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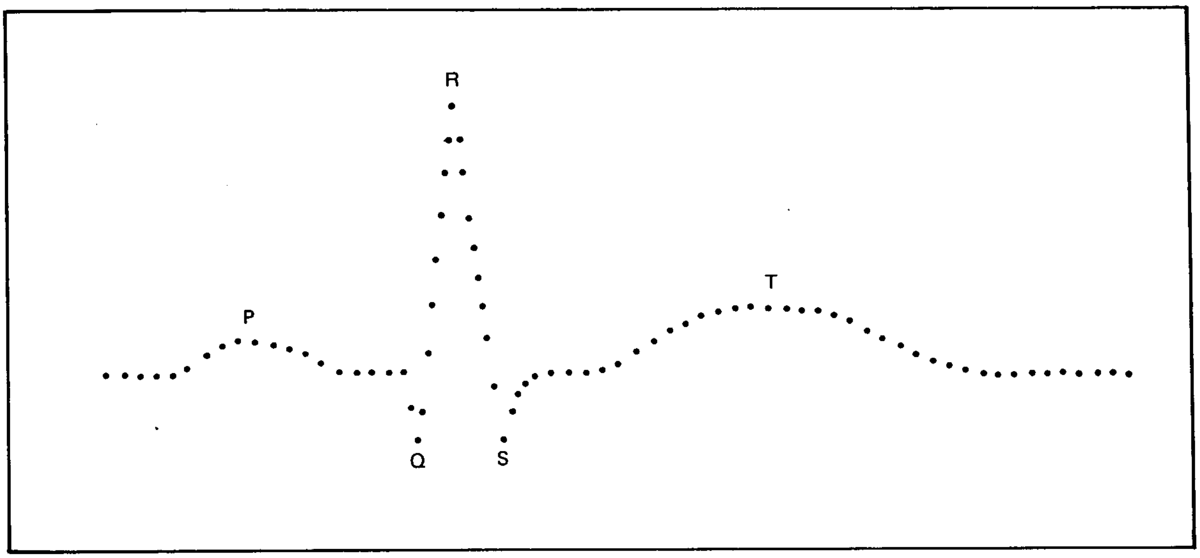
NASA TECH BRIEF
Manned Spacecraft Center

Compression and R-Wave Detection of ECG/VCG Data



Digitized ECG Wave Form

The problem:

When electrocardiograms (ECG'S) and vectorcardiograms (VCG's) are digitally processed, as is often the case in many fields of study today, a great mass of data is transmitted and stored on magnetic tape. Because cardiac cycles are quite redundant, the changes in an ECG or VCG wave form are the primary elements used for analysis. A reliable method of eliminating the repetitive part of the data from data processing would save important time in computer processing, storage and transmission of digital cardiac data.

The solution:

Information theory is used to eliminate the redundant part of an ECG or VCG wave form from data transmission and computer storage.

How it's done:

An ECG measures the electrical impulses generated by the heart; electrodes placed on the arms, legs, and chest, are connected in sequence to a galvanometer from which the signals are read and recorded. A VCG uses several electrodes simultaneously on the front, back, and side of the patient's torso to get a three dimensional study of the heart's electrical activity. In both cases the wave form (see figure) is primarily sinusodial. Once digitized for computer compatibility, the amount of data needed to analyze the ECG/VCG wave forms can be reduced by a transformation alogrithm. When used for this purpose a Fast Fourier Transform reduces the data needed to analyze the wave form by a factor of sixteen with a reconstructed root-mean-square error of only six percent. The Fast Fourier Transform accomplishes the data compression by changing the usual time domain representation of the signal to one of frequency representation. A representation of the ECG or VCG signal requires less data in the frequency domain than in the original time domain. A Hadamard Transform may also be used in a similar manner to yield a data compression factor of eleven.

(continued overleaf)

Digital processing of cardiac data depends on computer recognition of a complete cardiac cycle (heart beat). The most prominent factor in a cardiac cycle is the R-wave (see figure). The R-wave can be determined in real time by a Peakedness Parameter technique which simply and reliably detects the R-peak regardless of the variabilities of ECG/VCG signal characteristics. A peakedness parameter is defined using the millivolt differences between the digital data points making up the rapidly rising and falling R-wave. In order to reduce the effect of random noise, millivolt differences are taken between data points eight samples apart. In the figure, the differences between data points (curve slope) are at first positive, i.e., rising, then negative on any positive peak. The peakedness parameter is defined as:

Peakedness = max. negative slope - max. positive slope.

Accordingly, the peakedness parameter is a negative number and the largest negative values will always occur on the R-Peak of the wave form. A pointed or peaked wave produces a large peakedness value; conversely, a more rounded wave produces a much smaller value. An appropriate threshold value is compared against each peakedness calculation. A peakedness calculation exceeding this threshold value is a sure detection of the R-wave.

Notes:

1. This technique may be used as a real time patient monitor in large hospitals and may be of interest to designers and users of biomedically oriented computer software.
2. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference: NASA CR-115177 (N71-35323), Final Project Report Investigation of Data Compression Techniques
3. Technical questions may be directed to:

   Technology Utilization Officer
   Manned SpacedraftCenter
   Code JM7
   Houston, Texas 77058
   Reference B72-10391

Patent status:

No patent action is contemplated by NASA.

Source: Waldo L. Hayden, Marshall F. Conover and, William P. Bennett of
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