Electro Cardio Acoustic Diagnostic (eCAD) tool

Namokarrah Enterprises (NE),
Mumbai, India

eCAD is a state-of-the-art non-invasive electro-acoustic sensing device and includes proprietary signal processing algorithms with fast DSP core hardware to ***detect and locate cardio and coronary vascular disease with almost pinpoint accuracy and in a very short time in real-time.***

The present system relates to preventing deterioration in the blockage of the coronary arteries due to the formation of plaque and, more particularly, to a method for determining the early location of such blockages in the coronary arteries to enable cardiologists to accurately perform the angiogram to repair the blockages before a catastrophic failure of the heart. Currently, invasive procedures, known as angiograms, are some of the technologies used for the diagnosis of the narrowing or blockage of the coronary arteries of the heart. The eCAD™ method is a ***non-invasive*** screening tool for assessing both the cardio and coronary conditions that can lead to myocardial infarctions.

Coronary artery disease generally refers to the buildup of cholesterol in the inside layers of the arteries. As shown in FIG. A, this will slowly narrow the flow of blood through the vessel, and the muscle it supplies will not get enough blood. The plaque weakens the wall. As shown in the lower artery, a crack may develop in the plaque and a blood clot may form - this is the mechanism of most heart attacks. When this blockage occurs in an artery it causes the blood to flow with more turbulence, which generates high frequency sounds especially during the diastolic activity of the heart. This high frequency signal represents an admissible kernel representation for using high end signal processing tools like wavelet transform (WT) in appropriate signal processing algorithms. High frequency bandwidth, spread spectrum signals that experience time and frequency scaling are difficult to decompose with narrowband analysis, such as Fourier transform, due to its sinusoidal kernel, which approximates the scaling effect with a Doppler shift. However, the WT uses a more general analysis kernel, or mother wavelet. This enables to assess the severity of signals both the in the systole and diastole sections of a heart beat. The former helps to assess the proper functions of the valves and the latter the coronary arteries. The signal processing techniques are adapted to the broad band and narrow-band features of WT to assess the above malfunctions.

A necessary part of the intervention process also involves cardiac catheterization, which is invasive. This process is required before the actual angiogram and the subsequent angioplasty procedures are conducted. In a typical cardiac catheterization process a catheter is inserted extending from the groin area to the heart. At the end of this catheter are suitable sensors. In some cases there are active sensor heads, which emit a radio frequency signal of 1

MHz and project it towards the heart. These sensor heads are almost within 1" from the heart border as shown in FIG. 1. The projected signal is reflected of the arteries of the heart and can show the location of the occlusion. Angioplasty may be done. It is the object of the present device to provide a novel method for detecting and determining the position of the blockages in the coronary arteries of the heart. It is also an object to provide such a method, which can be readily, reliably and economically achieved. Another object is to provide novel apparatus to conduct the detection and location of the blockage in the coronary arteries. A further object is to provide such an apparatus, which may be fabricated from readily available components at a reasonable cost to enable its widespread use. This apparatus should be able to provide the detection of the stenoses in the coronary arteries and their location in relation to the reference origin, in this case considered as the base of the sternum as shown in FIG. 1.

eCAD is a non-invasive device for detecting coronary artery disease and erroneous functions of the heart valves to assess cardio fidelity. Normal biomedical signals like the systolic and diastolic motions of the heart are generally stationary. Coronary occlusions, however, create turbulence, related to the diastolic motion, making these signals non-stationary which can be detected acoustically. The acoustic signature of the turbulence can be studied using fractal analysis and wavelet transforms. The result is an estimation of an occlusion in the coronary arteries.

In addition, the eCAD system by NE is composed of three parts:

1. Four Sensors, one of which is an EKG sensor.
2. A personal computer for signal processing and signal processing algorithms (i.e. wavelet transformations) to estimate the occlusion and malfunctions of the heart valves.
3. Algorithms to remove signal noise (normal functioning of the heart), and to locate the coordinates of possible stenoses and locate the malfunctioning heart valve.

Figure 1 contains a schematic indicating the location of the sensors in relation to the heart, ribs, and base of the sternum. Generally all the sensors are acoustic sensors like microphones or piezo-electric crystals. For calibration purposes an R-wave sensor is used as $sensor_D$.

The procedure is straightforward and simple. Data is collected from the sensors on the chest of the patient at four points as indicated in FIG. 2. A typical signal is shown in FIG. 3.

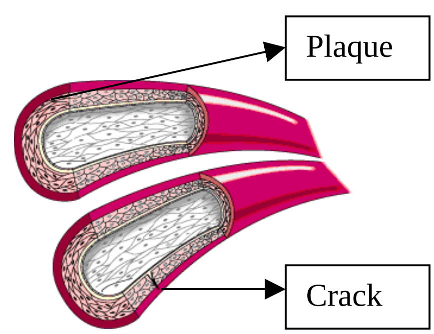


Fig. 1 Formation of plaque and crack in the wall of a coronary artery

Figure 2.
Location of Sensors
In Relation to the Heart, Ribs, and Base of the Sternum

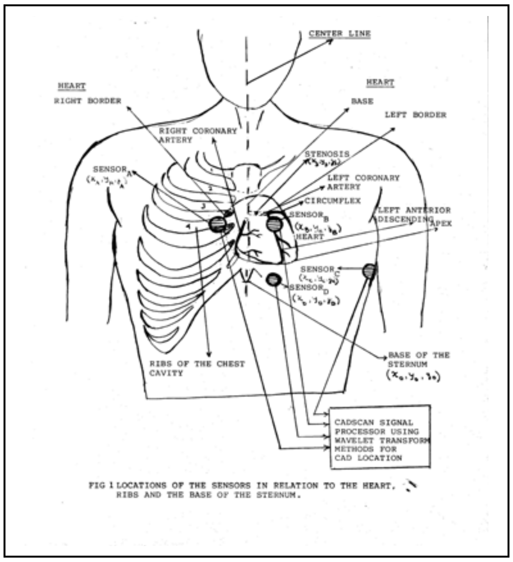
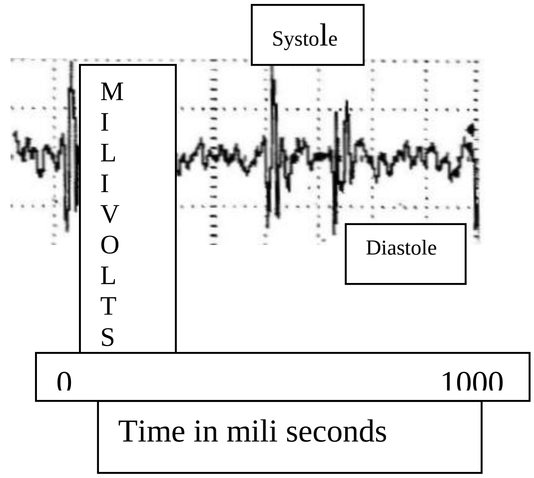


Figure 3
A typical heart signal



The systole part of the signal is utilized to assess the functioning of the opening and closing of the heart valves for a unidirectional flow from the auricles to the ventricles. Approximately this is for the first 300 msecs of the heart bit as shown in Fig 2.

The diastolic part of the signal is utilized to assess the stenosis in the coronary arteries. The algorithms in the eCAD system perform wavelet transforms which provide both frequency and time domain analysis. A scaling factor and translation parameters associated with the frequency of the turbulence and vibrations of the heart are applied to obtain estimates of the time delays for the pulse of sensors and the estimates of the transformed and scaled signals. These parameters are then evaluated to determine the estimated position of the occlusion in the coronary arteries of the heart. This is for the remaining 700 msecs of the heart bit as shown in Figure 3.