CARDIOMETRIC HEART SOUNDS DIAGNOSTIC SYSTEM

Project Overview

This project is based on the transfer of acoustic pattern recognition technology developed by NASA, DoD and several Universities to the Health Care Industry for humanitarian purposes. Specifically, to that part of medicine that deals with the heart and lungs. For decades acoustic pattern recognition has been used to identify sound emitting sources in the ocean, in the air, in the ground as well as individual human speech patterns. This project uses these techniques to identify abnormal sounds made by the beating of the human heart and inflation and deflation of the human lungs for the purpose of early diagnosis of abnormal function.

Project Overview Continued

The stethoscope provides the Physician with the ability to listen to heart and airway flow sounds. Unfortunately, this first step diagnostic tool is limited by a Physician's hearing ability and knowledge of heart and lung sounds. Trained cardiologist have acute hearing skills in this area, however thousands of other Physicians and Health Care Professionals do not have these acute hearing skills. A clear example of this is the gynecologist who sometimes is the only Physician from which a woman seeks treatment. Gynecologists are not typically specialist in detecting early indications of heart or lung abnormalities and may miss the early symptoms.

Therefore, to facilitate this gap in the Health Care Industry, this project applies computerized acoustic pattern recognition techniques to assist all health care professionals and individual users with an online diagnostic service useable in a home, office, mobile, field, or clinical environment.

Project Overview Continued

The **product** associated with this project is a **Cardiometric Spectral Imaging** (**CSI)** unit that applies the aforementioned computerized acoustic pattern recognition technology to assist in identifying abnormal heart and lung function. A **CSI** unit can alert the user, Physician or Health Care Professional to seek further consultation regarding cardiac or respiratory health issues. Additionally, users involved in rigorous exercise or sports activities can use the **CSI** unit to continuously monitor cardiac and respiratory function.

The CSI unit consist of a special low frequency acoustic sensor and a sensor interface module (SIM) attached to an associated SmartPhone running application software that processes the heart sound data from the acoustic sensor.

ACOUSTIC SENSOR

ASSOCIATED SIM/SmartPhone

HOW IT WORKS

The **CSI** unit includes two components, a ¾" diameter Acoustical Sensor and a Sensor Interface Module (**SIM**) attached to the back of an associated **SmartPhone** or PC). The acoustic sensor/**SIM** performs the function of the diaphragm on a stethoscope and the application software running on a **SmartPhone** or PC replaces the Health Care Professional's listening function. Hence, the sound recognition that is usually performed by the person using a stethoscope is done by mathematical algorithms implemented in software running on the **SmartPhone** or PC.

Typical heart sounds identifiable by the **CSI** unit include:

Normal Heart Sounds

Left Ventricular Hypertrophy (Abnormal Heart Sounds; S4 Gallop)

Mitral Valve Prolapse (Abnormal Heart Sounds; Click)

Both Normal and Cardiomyopathy (Abnormal Condition; S3 Gallop)

Acute Mitral Regurg (Abnormal Heart Sounds)

Mid Systolic Murmur, Mitral Regurg due to CAD (Abnormal Heart Sounds)

Late Systolic Murmur, Mitral Regurg due to MVP (Abnormal Heart Sounds)

Holosystolic Murmur (Abnormal Heart Sounds) (Adnormal Heart Sounds)

S4 and Mid Systolic Murmur (Abnormal Heart Sounds)

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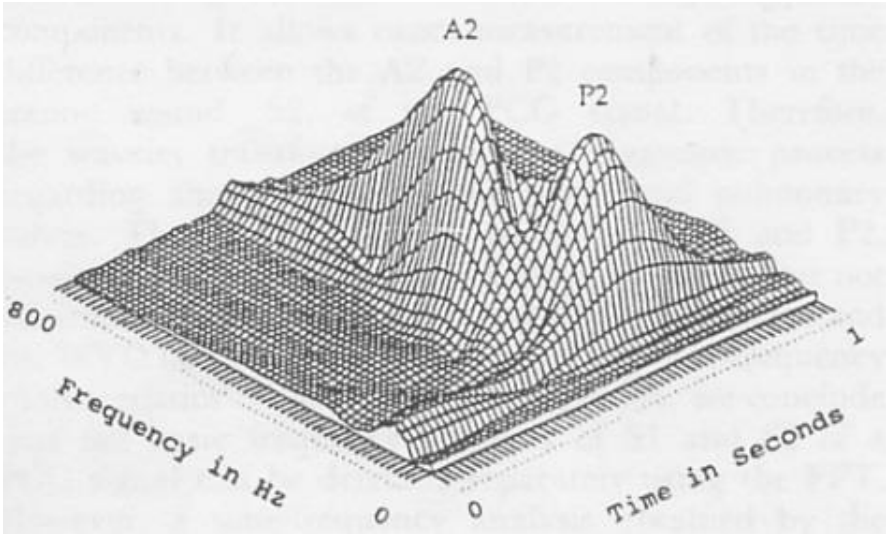
Mitral Stenosis (Abnormal Heart Sounds)

The current template library includes 12 normal and 96 abnormal heart sounds.

HOW IT WORKS

To use the CSI unit, the Acoustics Sensor is placed on the chest (near sternum) of the subject where heart sound data is picked up and processed by the **SmartPhone** or PC. The **SmartPhone** or PC in turn communicates with the Cardiometric Processing Center where the computer executed diagnosis is performed by creating a Cardiometric contour which is then compared to a library of contours (i.e. templates) to determine if the subject's heart sounds match known heart abnormalities or is normal.



CARDIOMETRIC CONTOUR

HOW IT WORKS CONTINUED

If the user's heart sound data is normal a green "NORMAL" symbol is sent back to the **SmartPhone** or PC. If the heart sound data is border line, a yellow "BORDERLINE" symbol is sent back. If an abnormality is detected, a red "ABNORMAL" alert symbol is sent back.

Optionally, the resulting Cardiometric contours from which the diagnostic messages were derived are sent back to the user and/or his Physician.

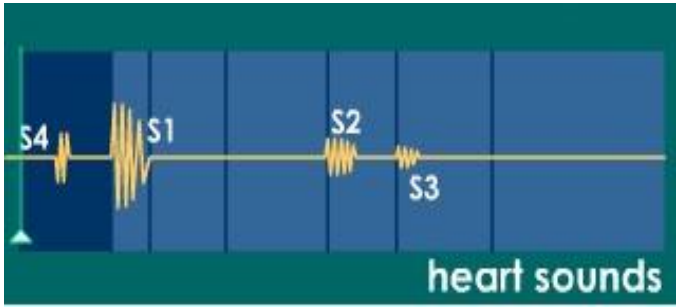
Optionally, the resulting computer aided diagnosis can be forwarded to the user's Physician via secure e-mail.

Optionally, heart/lung function metrics can be displayed on the users **SmartPhone** or PC device (i.e. heart rate, estimated blood pressure, respiratory rate, estimated lung efficiency, etc.).

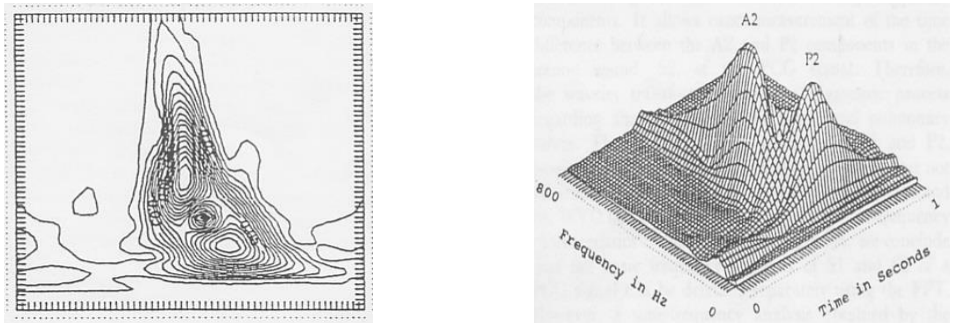
The CSI unit is simply a user interface to a heart/lung sound diagnostic service hosted at a remote server farm. The CSI unit is analogous to a Cable TV set top box connected to an online Media Service.

THE SCIENCE

Cardiometrics is the non-invasive process by which heart sounds (S1 thru S4) are time-spectrum analyzed and presented as three-dimensional contours. These contours can be used to assist in the early identification and detection of heart abnormalities and disease.



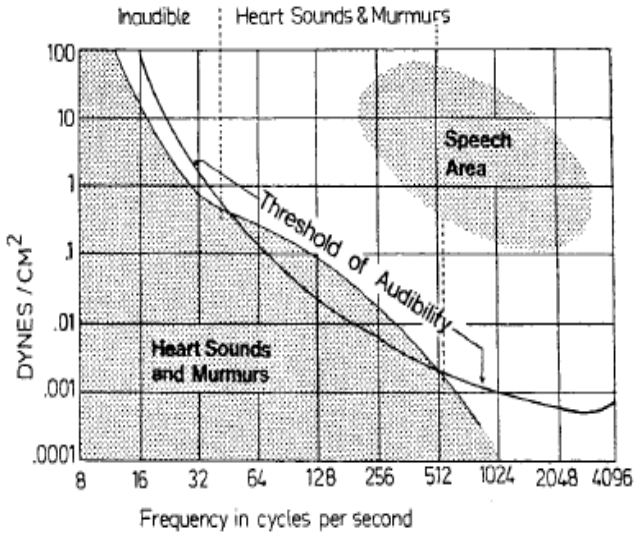
Typical S1 to S4 Human Heart Sounds



2D and 3D Cardiometric Contours

THE SCIENCE CONTINUED

The human heart produces sounds and murmurs in the 3Hz to 1000Hz range. Auscultation of these sounds with a stethoscope is limited by a Physician's ability to hear sounds between 3Hz and 40Hz with a stethoscope where abnormal sounds and murmurs are easily identified.



Human Ear Frequency Response

THE SCIENCE CONTINUED

The Contour database signature templates are automatically updated based on patient **CSI** data that has been verified by other conventional examination procedures, hence, the **CSI** database automatically "learns" with time (i.e. artificial intelligence).

Time-Spectrum Analysis in the 3 Hz to 1000 Hz frequency range coupled to a comprehensive database of abnormal heart sound contour templates, is the key to the Cardiometric computer assisted diagnosis technique.

THE PROJECT

The Project Timeline

Interface Module Construction	August 2017
Sensor Electronics Hardware Complete	September 2017
Unit Integration Complete	November 2017
CSI units packaged for Investor Reward Shipment	December 2017

The Project Team

Members of the project team are listed below:

C. F Motley (BSEE, MSEE/BME, MD PhD),
Richard Williams MD, Cardiologist (UCLA Medical Center),
Tracey Brooks MD, (Massachusetts General Hospital),
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David Rolandelli (BSEE, MSCS),
Frank Fei, (BSCS, MSCS), and
E. P. Motley (BSCHE).

Project Status

- Currently constructing first **CSI** prototypes (i.e. Sensor Interface Module).
- Testing and integrating application software (Porting software to **SmartPhone**)