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BE503 Mini Project
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ELECTRONIC STETHOSCOPE

Idea:

There are different types of stethoscopes available, mainly the acoustic stethoscope and electronic stethoscope. Acoustic stethoscopes operate on the transmission of sound from the chest piece whereas electronic stethoscopes convert the acoustic sound waves obtained into electrical signals. The sound level of acoustic stethoscopes is quite low, which is an issue. An electronic stethoscope electronically amplifies the body sounds and thus overcomes the low sound levels. The electrical signals that have been transformed can also be digitalized for additional processing and transmission. For this project, we'll be fetching the raw heartbeat sound data from online public databases, and will proceed with our model of electronic stethoscope with that.

As such, our client requests a redesigned electronic stethoscope consisting of a main receiver box, with both speakers and a headphone jack for listening, along with two wireless microphones that attach to the patient and detect the heart and lung sounds. The final prototype utilizes two microphones whose signals are sent through a quad amp which implements an initial gain of three and filters the input via a five pole Sallen-Key low pass filter. The two filtered signals are then sent to a mixer, which allows the user to select which input microphone they would like to use and adjust the bass and treble characteristics of the signal. Following the mixer, the signal is sent to another switch, which allows the user to choose between headphone or speaker output. Future work includes continued work to refine our circuit, and implementing wireless technology for transmission of the microphone signal. After implementing these two improvements, the circuitry would be wire wrapped, or printed on a circuit board, in order to fit it into the existing speaker case.

Objective:

The specific objectives of this project are:

- Conversion of acoustic sound waves to electrical signals.
- Pre-processing of auscultation signals, involving removal of interference noise and separation of respiratory noises, and amplification of the signals.
- Transmitting the heart sounds signal to a personal computer using a graphical user interface for analysis and to build-up the data-base for replay, demonstration or consultation purposes.
- Calculation and display of heart beat rate.

Tasks involved:

There will be three modules:
Data Acquisition module, Pre-Processing module and Signal Processing module.

1. Data Acquisition Module: Heart Sounds are recorded and converted into digital signals and sent to the pre-processing module.

(i) Electronic stethoscope sensor -
raw heartbeat sound data from online public databases to be used.

(ii) Amplification and filtering -
Two main classes of amplifiers were considered for signal amplification, AB and D. Both act in similar fashions, taking power from a source and using it to increase the amplitude of a signal while maintaining the input signal's shape

(iii) Analog-to-digital converter -
ADC used. Usually, a higher sampling rate and bit resolution will provide greater accuracy, at the cost of more bandwidth required and power consumption.

2. Pre-processing module: The filtered and interference reduced signal is normalized and segmented.

(i) Signal denoising unit

(ii) Normalization and segmentation (HS signals are normalized to a certain scale, so that the expected amplitude of the signal is not affected from the data acquisition locations and different samples)

3. Signal Processing module: Feature extraction and classification are carried out. The output of the system is the classification result for clinical diagnostic decision making.

Validation of Results:

We would validate our results by ensuring that:

- The amplifiers used amplify the signal to the right amount.
- The denoising doesn't deteriorate the feature signal characteristics.

Sensor Design:
The capacitive MEMS (Micro-electro-mechanical system) sensor has the advantage of small size, mass production and better temperature stability. In addition, it is compatible with conventional complementary metal-oxide-semiconductor (CMOS) technology; hence, when combined with an integrated circuit it makes it possible to develop a high performance HS sensor system.