

Apply It.

The math behind...

Hearing a fetal heartbeat



Technical terms used:

Electrocardiogram (ECG), Independent Component Analysis (ICA), ultrasound, electrode

Uses and applications:

Non-intrusive ECG of a fetus inside a mother's womb. ICA also has applications in EEG (brain activity monitoring), finance, image processing and signal processing

How it works:

It is often desirable to monitor the cardiac activity (ECG) of a fetus inside a mother's womb. Although easy to use, the classical ultrasound techniques may be inconclusive in some cases.

As a safe and comfortable alternative, we can place electrodes (a kind of microphone for electrical signals) on the mother's abdomen. The issue is that these electrodes will pick up the ECG signals from both the mother and the fetus, as well as noise. These signals reach the different electrodes and are superposed into a single signal, making it impossible to differentiate them.

Luckily, the superposition is different for each electrode. For example, the one closest to the mother's heart will record the mother's cardiac activity more precisely than the other electrodes. A mathematical technique called Independent Component Analysis (ICA) exploits this difference. It is based on the assumption that the original ECG signals are "independent" of each other, i.e., they do not, a priori, look alike. In essence, ICA defines how plausible a separation of the recorded signals is, and provides a means of finding the most plausible separation. When done right, this will yield separate ECG's for the mother and her fetus.

The development of ICA techniques is a modern research topic in applied mathematics, as demonstrated by a wealth of papers published about it this year.

Interesting fact:

For identical twins, the matter is even more crucial. They are indeed 9 to 15 times as likely to develop a cardiac defect as other fetuses and make for an even more challenging situation for ultrasounds. ICA techniques can handle this naturally.

References:

Sridhar-Keralapura, M., Pourfathi, M. & Sirkeci-Mergen, B. (2010). Independent Component Analysis With Data-Centric Contrast Functions For Separating Maternal And Twin Fetal ECG. Proceedings of the World Congress on Engineering and Computer Science, Vol II (October 2010).

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