Public summary of PhD-thesis of Brian Bloemendal
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Extracting a specific signal from among many

Think of a time when you had a conversation in a noisy environment such as a café. In such a situation, the signal from a desired source (what your conversation partner is saying) is mixed with other sources (the other people in the café, background music, etc.). Human ears are good at following a conversation in a setting like this. For computers, source extraction is difficult, especially when the sources are simultaneously active. In my thesis, I modeled scenarios where I measure mixed source signals with multiple sensors. The goal: to extract the desired source signal using a minimum amount of information.

Researchers have been trying to extract single, desired source signals for a long time. However, the question is getting more and more complex. Consider speech. Ten years ago, people spoke directly into their phones. 5 years ago, people were using their phones in speaker mode even while walking around. And today, people want to be able to talk to Siri, Cortana, Alexa or Google across a noisy living room and be understood. The desired source is often no longer the loudest. But source extraction is also important in other fields. An electrocardiogram (ECG) of a pregnant woman, for instance, contains a mixture of the heart signal from both the fetus and the mother, while the goal is usually to only check on the fetus.

Usually, source extraction is done by applying a digital filter to each sensor signal and doing a calculation with the filtered signals. Designing the settings for those digital filters is often challenging. In my thesis, I provide insight in the source extraction problem and have developed and designed source extraction algorithms that guarantee immediate extraction of the desired source. These algorithms can in the future be used by developers of multi-sensor applications to help them extract specific sources, improving on today’s data-driven approaches.

Data-driven or blind approaches to estimating the most effective filter settings are currently the preferred alternative to model-based techniques. Blind methods use much less information about the source signals and the way in which sources are mixed, and estimate filter coefficients directly from the measured signals. However, currently available blind solutions for this source extraction problem typically separate all the sources in the mixture (which takes a lot of computing power) or randomly extract only one of the sources (which may not be the one you are looking for).

My approach combines aspects from both approaches: I incorporate just enough available information about the desired source to design an algorithm that is guaranteed to extract the right source immediately. I formulated a series of mathematical optimization problems that result in exactly the right filter coefficients. I also discuss how to design these optimization problems. Also, I discuss what kind of information you need in advance so you can guarantee extraction of the desired source, for example information about the mixing (the location of the person you want to hear) or about statistical properties of the desired source (we are looking for a woman talking).

Title of PhD-thesis: Informed source extraction from a mixture of sources exploiting second order temporal structure. Supervisors: Jan Bergmans, Piet Sommen (TU/e), Jakob van de Laar (Philips Research). Other main parties involved: Philips Research