

Review of “Independent Component Analysis: A
Tutorial Introduction” by James V. Stone, MIT
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Independent Component Analysis (ICA) is a technique for separating a mixture of signals into its components. As this very clear and competent tutorial explains, the canonical example of ICA is as follows. Consider we have two people speaking in the same room, and we record their speech using microphones. Wouldn't it be useful to be able to filter out each of the voices in turn, so that we can produce a recording of just the voice we are interested in, rather than having a recording of the voice we are interested in with the other voice overlaid? ICA is a mechanism that allows us to do just that.

There are, of course, a number of signal processing techniques that make this kind of analysis possible, all of which can take a mixture of signals and extract components of that mixture. The difference with ICA is whereas the techniques of *principle component analysis* and *factor analysis* extract signals that are uncorrelated, independent component analysis extracts signals that are statistically independent. The idea behind doing this is that if the components of the combined signal are from distinct physical processes then these components will be statistically independent. Turning this around — which is logically invalid, but works in practice — if one can extract statistically independent signals from some mixture, then they must be from distinct physical processes. Of course, in practice the mechanism that allows one to “extract statistically independent signals” is somewhat complex, but the overall approach has a beautiful simplicity to it, and one that comes across fully in *Independent Component Analysis*. It is also a technique that is increasingly being adopted for the analysis of high-dimensional data, making the book very timely.

Overall this is an excellent book, one that could easily form the basis for a course at the graduate level, or for self-study by graduate students and post-doctoral researchers. In fact, given the clear and careful explanation, and fact that the book contains all the necessary mathematical background, it could probably be used by unaided undergraduate students as well — in that sense it is very much a model textbook.

The structure of *Independent Component Analysis* is also a model for other authors. It opens with a chapter describing independent component analysis at a high level, followed by a chapter that briefly sketches general issues in blind source separation — the general class of techniques of which independent component analysis is one. This introductory material is followed by two chapters on the basic mathematical model that describes the mixing and unmixing of signals, and then a chapter on the relevant concepts from probability theory and statistics. At this point all the preliminaries are over, and the book focuses in on techniques for blind source separation. Three such techniques are presented, each in a separate chapter. The first to be described is *projection pursuit*, which extracts signals from a mixture in such a way that the probability distributions of the signals are as ungaussian as possible. This is followed by central, and indeed longest, chapter of the book which explains how ICA itself works, using, as mentioned above, the idea of extracting statistically independent signals. The third technique to be considered is *complexity pursuit*, where one aims to extract the simplest possible component signals from a mixture. Now, all of these approaches could be implemented through an exhaustive search of possible components, but as the next chapter describes it is more efficient to use a form of hill-climbing through the space of possible signals, and this material is then followed by two final chapters, one on the alternative approaches of principal component analysis and factor analysis, and the last giving some applications of ICA. Many of the techniques described in the central chapters are demonstrated with MatLab code which is available both in appendices and from the website for the book.

In summary, *Independent Component Analysis* is well thought out and well written, provides a concise and easily understandable introduction to its topic, and deserves to be the basic text on ICA for some time to come.