Gauss Prize Citation

David Donoho, Stanford University

for his fundamental contributions to the mathematical, statistical and computational analysis of important problems in signal processing
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Large amount of data is today generated at an increasingly accelerated pace. Processing it by sampling, compression and denoising has become an essential undertaking.

David Donoho has throughout his remarkable research career helped us make sense of data, which often is in the form of signals and images. His research transcends boundaries between mathematics, statistics and data science. The contributions range from deep mathematical and statistical theories to efficient computational algorithms and their applications.

Already in his early research Donoho was reaching outside of the main stream of classical applied mathematics and statistics. He understood the importance of sparse representation and optimization in signal processing. He also recognized the power of wavelet type representations for a variety of tasks in signal and image analysis. One example is his work with Johnstone, where they exploit sparsity in wavelet representations together with soft thresholding for enhanced signal estimation and denoising.

The development, analysis and application of curvelets by Donoho and collaborators introduced another powerful tool in sparse image representation. While wavelets can be seen as a generalization of delta functions and Fourier expansions by using a basis that represents both location and frequency, curvelets go further by adding localization in orientation. Much of what wavelets do for one-dimensional signals curvelets can do for multi-dimensional data. Efficient representation and processing of images with edges are natural and successful applications.

Compressed sensing is a technique for efficiently sampling and reconstructing a signal by exploiting sparsity in an incoherent representation and thus beating the classical limit on the required sampling rate imposed by the Nyquist–Shannon sampling theorem. This technique has, for example, been applied to shorten magnetic resonance imaging scanning sessions. Donoho and collaborators have contributed to develop and refine this powerful theory. He showed that one could solve some types of underdetermined linear systems via L1-minimization provided that the solution is sufficiently sparse. He derived the existence of sharp transitions for the recovery of sparse signals from special kinds of random measurements.

David Donoho stands out in his ability to bring together pure and applied aspects of mathematics and statistics. He has had a fundamental influence by his original research, and also by his writing and mentoring of students and postdocs.