Compressed Sensing - Basics and Some New Results

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Abstract:

Compressive sensing (CS) is a powerful technique to represent signals at a sub-Nyquist sampling rate while retaining the capacity of perfect (or near perfect) reconstruction of the signal, provided the signal is known to be sparse in some domain. Having come up formally in the first decade of this century, it grew rapidly in subsequent years embracing a wide array of fields like applied mathematics, statistics, and engineering, including signal processing ar- eas like MR imaging, speech processing, analog to digital conversion etc. In CS, one takes a set of random linear projections, called measurements, of a signal vector, with the number of measurements being far less than the number of sam- ples. This results in an underdetermined linear system like $\mathbf{y} = \mathbf{A}\mathbf{x}$, where $\mathbf{A}$ is a so-called $m \times n$ sensing matrix with $m << n$, $\mathbf{x}$ is an unknown, sparse vector and $\mathbf{y}$ is the measurement vector. In CS, one can recover $\mathbf{x}$ uniquely from $\mathbf{y}$ by imposing certain constraints on $\mathbf{A}$ in terms of its restricted isometric constant (RIC). In last two decades, several algorithms have come up for recovery of $\mathbf{x}$ from $\mathbf{y}$. One class of algorithms uses l_1 norm based convex relaxation techniques like basis pursuit, LASSO, basis pursuit denoising etc. Separately, several greedy recovery algorithms have been proposed like the orthogonal matching pursuit (OMP), compressive sampling matching pursuit (CoSaMP), subspace pursuit, iterative hard thresholding, hard thresholding pursuit etc which too use condi- tions on the RIC of $\mathbf{A}$ and determine the sparsest solution iteratively.

This talk will first introduce the audience to the basics of CS. This may be particularly useful to those who have not enough background in CS but who may need knowledge of CS in their research. This will be followed by some recent developments in CS. In particular, the talk will present the speaker's recent work on power series based hard thresholding algorithms, where the cost function is modified by a power series in $\mathbf{A}\mathbf{A}^H$. For appropriate choice of the power series coefficients, the proposed treatment not only leads to various ex- isting hard thresholding based recovery algorithms, but, more importantly, it enables one to develop new algorithms belonging to this category. Convergence and related results of the proposed method will be discussed.

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Mrityunjoy Chakraborty received Bachelor of Engg. in Electronics and Telecommunication Engg. from Jadavpur University, Kolkata (1983), Master of Technology (1985) and Doctor of Philosophy (1994) both in Electrical Engg. respectively from Indian Institute of Technology at Kanpur and Delhi. He joined the department of Electronics and Electrical Communication Engg. at the Indian Institute of Technology, Kharagpur as a lecturer in 1994 and is currently a Prithviraj and Swati Banerjee chair professor in the same department, with teaching and research interests in digital and adaptive signal processing, VLSI signal processing, linear algebra and compressive sensing.

He has served the IEEE Transactions on Circuits and Systems, part I (2004-2007, 2010-2012) and part II (2008-2009, 2022-2023) as an Associate Editor, apart from being a Senior Editorial Board (SEB) member of the IEEE Signal Processing Magazine (2017-2020) and a SEB member of the IEEE journal on Emerging Techniques in Circuits and Systems (2016-2017). He was elected as a Chair of the DSP Technical Committee (TC) of the IEEE Circuits and Systems Society during 2016-2018. He has also been a Guest Editor of the EURASIP JASP and special issues of TCAS-II, DSP track Co-Chair of ISCAS 2015-2024, TPC Co-Chair of IEEE SIPS-2018, Special Session Co-Chair of DSP-18 and a Gabor Track Chair of DSP-15. He is a co-founder of the Asia Pacific Signal and Information Processing Association (APSIPA), has been a member of the APSIPA BOG (2013-2016) and also, served as Chair of the APSIPA TC on Signal and Information Processing Theory and Methods. He has also been the General Chair of the National Conference on Communications - 2012, 2020.

Prof. Chakraborty is a Fellow of the National Academy of Sciences, India, and also of the Indian National Academy of Engineering (INAE). Recently he received the prestigious Chair Professorship of the INAE. During 2012-2013, he was selected as a Distinguished Lecturer of the APSIPA.