

Sparse and Redundant Representations: From Theory to Applications in Signal and Image Processing

By Michael Elad

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A long long time ago, echoing philosophical and aesthetic principles that existed since antiquity, William of Ockham enounced the principle of parsimony, better known today as Ockham's razor: "Entities should not be multiplied without neces sity. " This principle enabled scientists to select the "best" physical laws and theories to explain the workings of the Universe and continued to guide scienti?c research, leadingtobeautifulresultslikethe minimaldescriptionlength approachtostatistical inference and the related Kolmogorov complexity approach to pattern recognition. However, notions of complexity and description length are subjective concepts anddependonthelanguage"spoken"whenpresentingideasandresults. The?eldof sparse representations, that recently underwent a Big Bang like expansion, explic itly deals with the Yin Yang interplay between the parsimony of descriptions and the "language" or "dictionary" used in them, and it became an extremely exciting area of investigation. It already yielded a rich crop of mathematically pleasing, deep and beautiful results that quickly translated into a wealth of practical engineering applications. You are holding in your hands the ?rst guide book to Sparseland, and I am sure you'll ?nd in it both familiar and new landscapes to see and admire, as well as ex cellent pointers that will help you ?nd further valuable treasures. Enjoy the journey to Sparseland! Haifa, Israel, December 2009 Alfred M. Bruckstein vii Preface This book was originally written to serve as the material for an advanced one semester (fourteen 2 hour lectures) graduate course for engineering students at the Technion, Israel.

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Editorial Review

Review

From the reviews:

“This book approaches sparse and redundant representations from an engineering perspective and emphasizes their use as a signal modeling tool and their application in image and signal processing. … This book is well suited to practitioners in the signals and image processing community … . The public availability of the source code used in the numerical experiments throughout the book could help students make the transition from theory to practice and allow them to get hands-on experience with the inner workings of the various algorithms.” (Ewout van den Berg, SIAM Review, Vol. 53 (4), 2011)

“The concept of sparse representations for signals and images is explored in the book under review. … The book offers an important and organized view of this field, setting the foundations of the future research. … The presented book is written to serve as the material for an advanced one-semester graduate course for engineering students. It will be of interest for all specialists working in the area of sparse and redundant representations application in signal and image processing.” (Tzvetan Semerdjiev, Zentralblatt MATH, Vol. 1211, 2011)

From the Back Cover
The field of sparse and redundant representation modeling has gone through a major revolution in the past two decades. This started with a series of algorithms for approximating the sparsest solutions of linear systems of equations, later to be followed by surprising theoretical results that guarantee these algorithms’ performance. With these contributions in place, major barriers in making this model practical and applicable were removed, and sparsity and redundancy became central, leading to state-of-the-art results in various disciplines. One of the main beneficiaries of this progress is the field of image processing, where this model has been shown to lead to unprecedented performance in various applications.
This book provides a comprehensive view of the topic of sparse and redundant representation modeling, and its use in signal and image processing. It offers a systematic and ordered exposure to the theoretical foundations of this data model, the numerical aspects of the involved algorithms, and the signal and image processing applications that benefit from these advancements. The book is well-written, presenting clearly the flow of the ideas that brought this field of research to its current achievements. It avoids a succession of theorems and proofs by providing an informal description of the analysis goals and building this way the path to the proofs. The applications described help the reader to better understand advanced and up-to-date concepts in signal and image processing.
Written as a text-book for a graduate course for engineering students, this book can also be used as an easy entry point for readers interested in stepping into this field, and for others already active in this area that are interested in expanding their understanding and knowledge.
The book is accompanied by a Matlab software package that reproduces most of the results demonstrated in the book. A link to the free software is available on springer.com.

About the Author
Michael Elad has been working at The Technion in Haifa, Israel, since 2003 and is currently an Associate Professor. He is one of the leaders in the field of sparse representations. He does prolific research in

mathematical signal processing with more than 60 publications in top ranked journals. He is very well recognized and respected in the scientific community.

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