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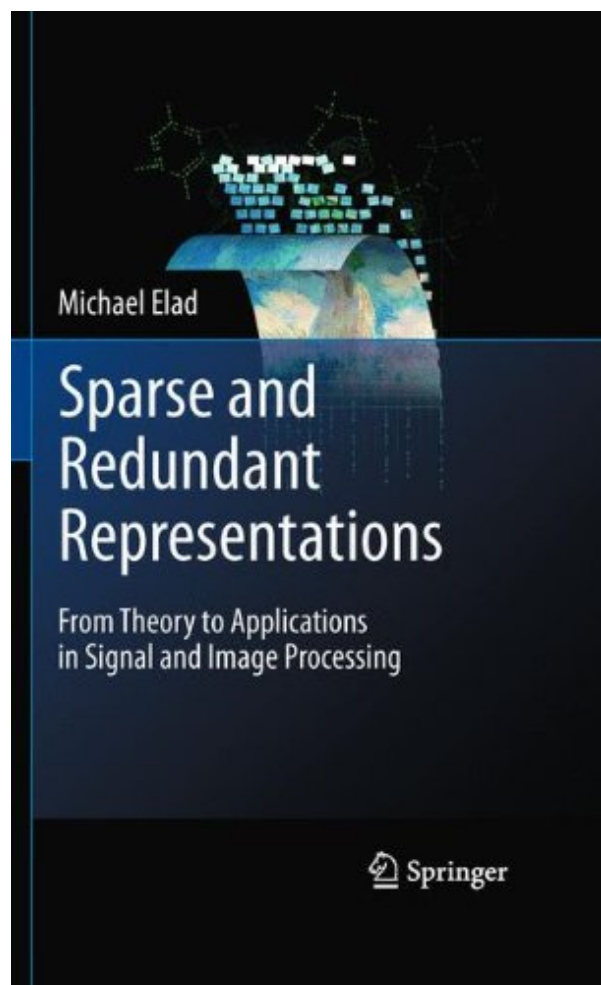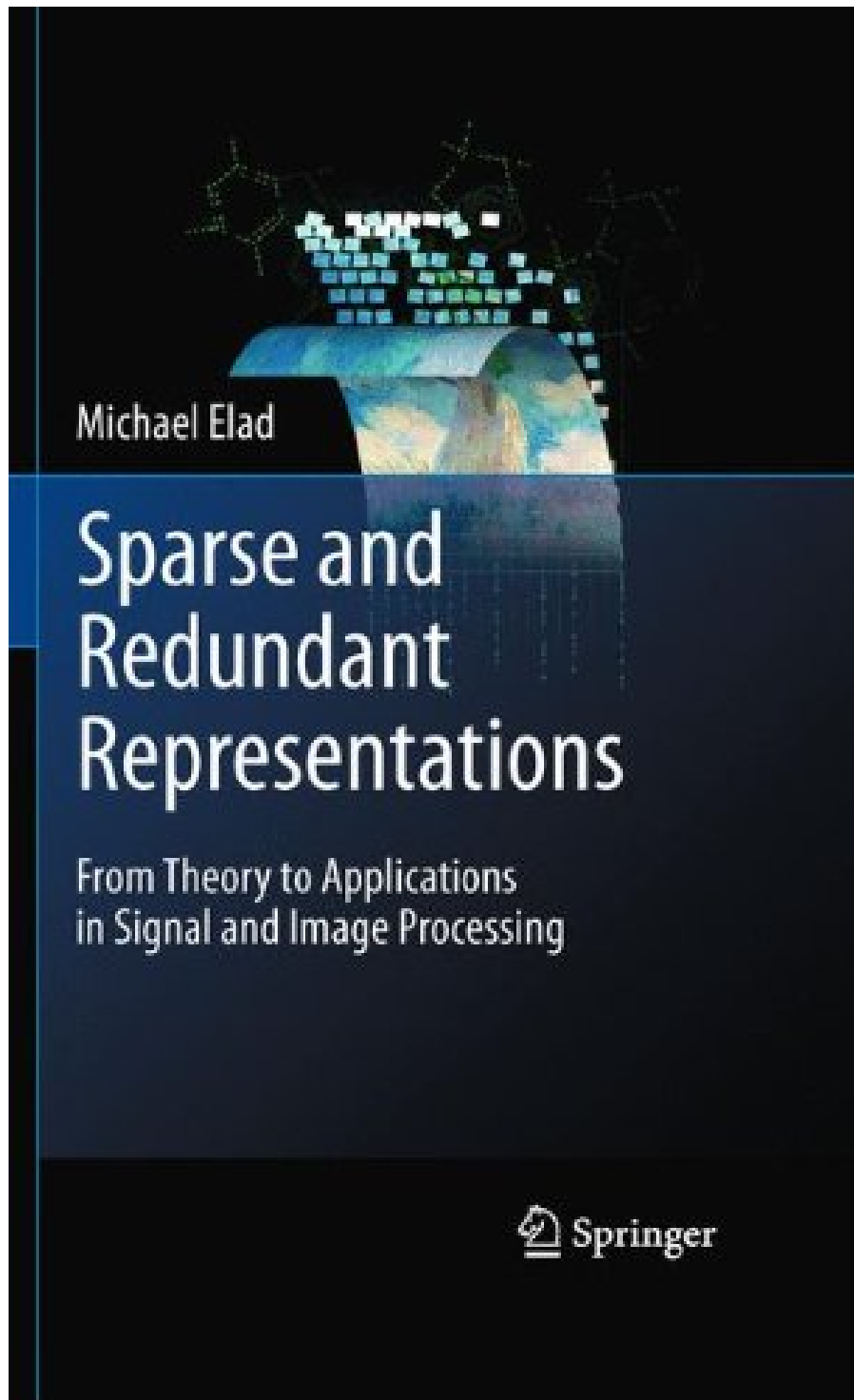
Michael Elad

Sparse and Redundant Representations

From Theory to Applications
in Signal and Image Processing

Springer

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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)

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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

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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, leadingtobeautifulresultsliketheminimaldescriptionlength 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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Most helpful customer reviews

17 of 18 people found the following review helpful.
Great book but has its limitations
By Manchor Ko
The book starts with a prologue of an under-determined linear system and how sparsity constraints help to solve it with the use of a Langrangian. Next the authors introduce the key idea of how certain norms promote sparsity. There are some good diagrams that really help the geometric intuition (though not as good as the ones by Donoho et al. in connection with Lasso). I really love the way they motivate and frame the entire field but still appeal to concept that most people who have studied linear algebra can relate to.

The first 6 chapters are a master piece in pedagogy. Except for the not so-standard usage of Spark as the measurement of coherence among elements of a dictionary. Mutual coherence is common and easier to grasp since it directly address the size of inner products. This leads to a rather jarring switch when RIP is introduced.

I am still puzzled why the authors do not appeal to frame theory. That leads to strange looking reference to

self-dual frames and tight frames when the book never talked about frames.

I also wonder why the authors did not cite Boyd's great book. The treatment of log-barrier was sort of just another penalty function. The term log-barrier was never used in the book.

Overall I cannot put the book down and was especially grateful to the authors for introducing iterative shrinkage as a central theme to link many modern numerical algorithms to solve the basic sparse optimization problem.

5 of 8 people found the following review helpful.
Very mathematical
By jjnbos
I'm a Math and Physics PhD from UCSD and I find this too much math and too little signal processing. Might not be a fair criticism but I didn't need to see a lot of proofs that IMHO are too brief to easily follow and too long to be interesting. If I was going to "fix" this, I'd skip the proofs and show a lot of toy examples for the algorithms: you know a 2x 5 matrix with small integers run for a few iterations. As it is too much theory to be practical, too much algo for a math book and so on...

9 of 11 people found the following review helpful.
Definitely a math book, but it teaches you step by step!
By Anne van Rossum
This book is about sparse representations. Mathematically it is all about solving:

min $\|x\|\_0$ subject to Ax=b

where $\|x\|\_0$ is a special type of "norm", it counts the nonzero entries in a vector x. And the issue at hand is that only a few columns in A will (multiplied by x) result in b. In other words, in many practical circumstances - apparently - this vector x only requires a few nonzero entries.

I am only on a third or so of the book (after one weekend), so I've to adjust my review later. Until now the authors do focus on trying to get theoretical grips on this topic. When is there a sparse solution? If you have one, can you find an even sparser one. I find many angles very interesting. That an uncertainty principles leads to a uniqueness result is amazing. The authors subsequently introduce the concept of a "spark" and are able to say if for example matching pursuit will succeed in recovering the sparsest solution.

In general the authors are using math all over the place, so if you don't like math stay away from the book. However, they take a very gentle approach from my perspective (as a robotics engineer), making quite some intermediate steps explicit. Of course, I have to go back some pages so now and then, but it's worthwhile. And I look forward to the second part of the book that describes the image processing applications, which after skimming looks much less "math-heavy", but where I hope the authors maintained the same pleasant level of detail.

See all 5 customer reviews...

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