PREFACE

Information seems to be a characterizing theme of the modern age. It is mentioned everywhere. Yet information as a subject of study is so vast that it is impossible to fully define its various aspects in a simple succinct statement. It is, instead, perhaps more fruitful to assume a rough understanding of the term, and then seriously study some of the important and interesting facets of the subject it represents. That is the approach taken by this text, which is an outgrowth of an undergraduate course taught at Stanford for the past few years. The approach is based on exploring five general areas of information, termed the five E's. They are entropy, economics, encryption, extraction, and emission. In fact, the text is divided into five parts, corresponding to these five areas.

The text, of course, does not attempt to cover everything about information. It is limited to covering only these five aspects of the "science" of information. However, the text is not designed to be a survey or overview. It is packed with specific concepts, most of which can be cast into mathematical or computational form and used to derive important results or explain observed phenomena. These concepts are used in derivations, examples, and end-of-chapter exercises. Indeed, a major objective is to present concepts that can be used in a number of areas, even beyond those directly related to information. In that sense the text is as much about general methods of analysis and design as it is about the subject of information. Much of the "science" of information science is portable to other fields.

The text is organized in the standard way, by parts, chapters, sections, and subsections. The chapters are more or less independent. Chapter 2 is basic and should be covered by all. Chapter 3 is also useful background, and some other chapters refer to sections of chapters 3 and 5. Although largely independent, the chapters are tied together by frequent reference to the concept of entropy and by the use of several common methods of analysis.

Some sections or subsections are marked with an asterisk (*), indicating that the material may be more difficult or that it can be safely skipped without loss of continuity. Likewise, some end-of-chapter exercises are marked with an asterisk, indicating that they are more challenging than most.

The level at which the text can be used is variable. At Stanford, students ranging from sophomores to graduate students have taken the course. There is no specific prerequisite; however, students of this text should have some level of comfort with mathematical reasoning: both for modeling and for finding answers. In terms of a standard phrase, students should know how to solve "word problems." The actual mathematics used is of several types. Elementary calculus is employed in some sections. Other sections use algebraic theory. Still others use probability. However, the mathematics that is beyond elementary calculus or algebra is introduced and explained. In that sense, the text is essentially self-contained with respect to the mathematics required. And since the chapters are largely independent, it is possible to select topics at various mathematical levels.

The complete text includes far more material than can be treated in a single academic quarter or even a semester. At Stanford I have covered about fourteen or fifteen of the twenty-two chapters in one quarter, although the particular choice of chapters has varied. Even this somewhat reduced agenda includes an enormous amount of subject material; after all, there are entire texts devoted to some of the material in individual chapters. How can so much be covered in a single academic course without seriously compromising depth?

I believe that rapid progress hinges on genuine student interest and motivation. These are derived from five main sources. First, inherent interest is typically strong for this subject. Many students plan to seek careers in the information industry, and this motivates a desire to learn about the field. Second, students are naturally curious about things they work with. How do compression algorithms such as JPEG and ZIP work? How is it possible to have a secure digital signature that cannot simply be copied? How does the Internet route millions of messages to their proper destinations? Third, interest is enhanced when students witness or participate in illustrative examples and experiments. The text includes such examples, and many of them can be used as experiments, as explained in the instructor's manual. Fourth, subjects come alive when students learn something about the individuals who pioneered in the area of study, learning, for example, whether someone's particular contribution occurred by happenstance or as the result of intense struggle. These little stories add a human dimension to the subject. Fifth, if a student works with the material, adding to it, finding a new way to present it, or exploring a new application, he or she becomes an owner rather than simply an observer of the subject. In the Stanford class, students worked in teams of four to develop projects of their choice that were presented in written and oral form. Many students felt this was the highlight of the class.

One objective of the text is to create a desire for further study of information science and the methods used to explore it. I hope that students studying this material will see the relevance of the tools that are employed and the excitement of the areas presented.

Development of this text and the underlying course has been a rewarding experience. It was made all the more pleasant by the encouragement and help that I received from many colleagues and students. I wish especially to thank Martin Hellman, Fouad Tobagi, Ashish Goel, and Thomas Weber for detailed professional feedback on parts of the manuscript. I also wish to thank Kahn Mason, Christopher Messer, Geraldine Hraban, and Mareza Larizadeh for help with development of the class itself. I appreciate Charles Feinstein, Wayne Whinston, Robert Thomas, and Sharan Jagpal for providing helpful comments on the entire manuscript. I want to thank Leon Steinmetz for the special drawings in the text and the staff at Princeton University Press for their creativity and hard work. And certainly, I am grateful for the helpful suggestions of the many bright and enthusiastic students who greatly influenced the development of this text.

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December 2005