
Book Reviews

SOLOMON W. GOLOMB, ROBERT E. PEILE AND ROBERT A. SCHOLTZ

Basic Concepts in Information Theory and Coding: The Adventures of Secret Agent 00111. Plenum Press. 1994. ISBN 0-306-44544-1. \$59.50. 431pp. hardbound.

While the adventures of typical successful secret agents inspire another Hollywood block-buster, the quite extraordinary professional life of secret agent 00111 is rather unique in that it inspired a book on Information Theory and Coding. I wonder how he would feel knowing that his 'biography' is being reviewed in, of all places, a computer journal!

The adventures apart, this is not just one more book on Information Theory and Coding. This book has a nice mathematical approach, yet it emphasizes the significance of the results wherever necessary. Even though the title gives a feeling that it is an introductory piece, some topics are covered in detail, and the ample insights provided throughout the text are far from superficial. It deals in depth with topics not ordinarily found in similar textbooks. These include logarithm as the only possible functional form of entropy, the Sardinas-Patterson algorithm for determining unique decodability, variable symbol duration channel's capacity, and self-synchronizing codes—as well as some works of the first author, such as comma free codes, information generating functions, and perfect code in the Lee metric. The information theory part is given much more emphasis than the coding part (USC connection?). In fact, no channel code, encoding, or decoding strategy has been covered, while source codes such as Huffman, Lempel-Ziv, run length and arithmetic have been detailed. The coding part primarily consists of bounds on channel codes, channel coding theorem, computing the capacity, and introductory discussion of the classes of channel codes (including FEC-ARQ scheme).

The problems provided at the end of each section are an asset to this book. Some important results have been presented through some of these problems. Citations are provided separately at the end of each chapter, which acts as an index. Among the niceties of this book are the motivation sections to the basic results of information theory and the sections discussing various bounds on channel codes. The text, with all its detours and subtleties, provides enjoyable reading.

Rather than using standard terminology, this book settles for unconventional phrases in a number of places. Prime examples are absence of terms 'arithmetic code' and 'Arimoto-Blahut algorithm'. Placement of run-length code and arithmetic code in chapter 4 (infinite discrete sources) rather than in chapter 2 (coding for discrete noiseless channels) is strange. The level of discussion has not been maintained at the same depth

throughout the book. Some parts contain too much detail and unnecessarily detailed flowcharts. More care should have been taken in drawing and captioning the figures. Topics that are remotely related and readily available elsewhere, such as Markov source, Chernoff bound, law of large numbers, convex functions, could have been avoided or put in the appendices.

ANAMITRA MAKUR

*Department of Electrical Communication Engineering
Indian Institute of Science
Bangalore, India*

J. L. KRIVINE

Lambda-calculus, Types and Models. Ellis Horwood. 1993. ISBN 0-13-062407-1. £49.95. 180pp. hardbound.

The λ -calculus has a central role in theoretical computer science. It provides the meta-language for denotational semantics and it has significantly influenced programming language design. Moreover, many properties, such as confluence and normalization, which appear in a pure form in the λ -calculus, recur in more complex calculi. Since the early 1980s, the community has been well-served by Barendregt's encyclopaedic tome, *The Lambda Calculus: Its Syntax and Semantics* (North-Holland, 1984); this is a superb reference work but it is not really suitable as the basis of a course for computer scientists. There have been a series of textbooks since the mid to late 1980s. Krivine's book first appeared in French in 1990; it is the course text for a D.E.A. (postgraduate) course at the University of Paris VII. The book is distinguished by giving one of the first textbook treatments of intersection types and Girard's System \mathcal{F} . I enjoyed the book and would certainly recommend it to PhD students and fellow researchers; I would not choose it as a course text for reasons that I will return to below after having reviewed the contents.

Chapter I concerns substitution and the basic theory. The treatment is fairly conventional; Krivine presents the notions of α , β and η conversion and normal forms. More surprisingly, he also presents proofs of the Church Rosser Theorem for β and $\beta\eta$ conversion; in many books, these are postponed to a more advanced chapter or appendix. He presents the Martin-Löf/Tait proof of the theorem for β -conversion which relies on a notion of 'grand' reduction (several reducible expressions being reduced at one time). There are standard references for this material such as Barendregt's book; therefore it is regrettable that Krivine has elected to use his own notation which will make it more difficult for the student to relate results to the standard literature. Two minor points that illustrate this last remark are the syntax of application terms, in which the applicator term is

parenthesized and the use of ' β -conversion' to designate what others have called ' β -reduction'.

The second chapter is about the representation of recursive functions. It starts with a treatment of head normal forms and solvability. Then it turns to the subject of representable functions (other authors use the term ' λ -definable' rather than 'representable'). This treatment is based on standard encodings for booleans and the Church numerals. Church's and Turing's fixed point combinators are introduced to provide an encoding for the minimization operator. The chapter concludes with a very brief treatment of the second fixed point theorem and Scott's theorem (that no two non-trivial sets which are closed under equality are recursively separable).

Chapter III introduces intersection type systems. This is one of the first presentations of this material in textbook form. The chapter starts by presenting the system $D\Omega$; this system has a type constant Ω which may be assigned to any term and, as a consequence, all terms are typable. Krivine goes on to provide a new proof of the normalization theorem: that under certain constraints on the occurrences of Ω in the type of a term t , t is normalizable by leftmost β -reduction. The second part of the chapter concerns a system, D , without the constant and it is shown that any term typable in this system is strongly normalizing (i.e. all reduction sequences from the term are terminating). This material is further developed in Chapter IV, which starts with subject reduction results but goes on to show that every strongly normalizable term is typable in D . Chapter IV is completed by a treatment of the finite developments theorem (which is new and attributed to M. Parigot) and the standardization theorem.

An important property of equational theories is that of *Hilbert Post completeness*: the theory has this property if every equation is either provable in it or adding the equation leads to an inconsistent theory. Bohm's theorem, which is the topic of Chapter V, shows that the theory of $\beta\eta$ -equivalence is Hilbert Post complete for terms having normal form. The theorem is based on the notion of *separability* of terms by establishing equivalence between each term and a distinct constant term. The material is presented in a fairly non-standard way which makes it difficult to relate it to standard texts such as Barendregt's book. This chapter is also quite short and technical, with no discussion about completeness.

Combinatory Logic is presented in Chapter VI. The chapter starts by presenting the basic combinators and the notions of *combinatory algebra* and *combinatory completeness*. Extensionality is axiomatised and the Scott-Meyer axioms for weakly extensional combinatory algebras and Curry's axioms are presented. The chapter concludes with a discussion of the relationship between the λ -calculus and combinatory logic. Krivine first shows that term models (and extensional term models) for the λ -calculus are also models for weakly extensional (and extensional) variants of combinatory logic. Mappings between λ - and combinatory logic terms are presented

and their relationships investigated. Chapter VI provides the necessary background for Chapter VII, which is a long chapter about models of the λ -calculus. As promised in the sleeve notes, this chapter provides practical, non-categorical techniques for building models. The chapter includes a description of some standard models from the literature such as $P(\omega)$, Engeler's model and D_∞ . The chapter concludes with a presentation of qualitative domains, stable functions and coherence spaces.

The last three chapters are devoted to Girard's System \mathcal{F} . Some of this material has appeared elsewhere, for example in Hindley and Seldin's *Introduction to Combinators and λ -calculus* (Cambridge University Press, 1986), but this is the first detailed textbook treatment. Chapter VIII introduces the system and presents subject reduction and strong normalization results. The chapter concludes with a discussion of data types (such as integers) in System \mathcal{F} . Chapter IX concerns second order functional arithmetic; the Curry-Howard isomorphism is illustrated in this setting and Krivine establishes a correspondence between System \mathcal{F} and the types of second order functional arithmetic. The chapter also addresses realizability interpretations, data types and the problem of how to program in second order functional arithmetic. The final chapter considers the class of numeric recursive functions which are representable in System \mathcal{F} .

In summary, this book provides useful reference material for PhD students and researchers in the area. I would not recommend it as a textbook for a number of reasons. Firstly, Krivine's decision to use non-standard notation and terminology makes it difficult for the novice to relate the material to the standard literature. Secondly, the book is clearly derived quite directly from course notes; in many places the text is a continuous stream of technical results and their proofs—Krivine has made no attempt to provide any intuitions or structural overviews of the theory. An example of this is the material on Bohm's theorem, which makes no mention of separability or Hilbert Post completeness. Thirdly, the bibliography is not very appropriate for a textbook; there are no citations in the text but relevant bibliographic details are given at the end of each chapter—the problem is that the author gives no hints as to the way in which the citations relate to specific parts of the chapter. Finally, I would expect a textbook to contain examples (of which there are very few) and exercises (of which there are none!).

C. L. HANKIN
Imperial College, London

A. W. ROSCOE (editor)

A Classical Mind: Essays in Honour of C. A. R. Hoare.
Prentice Hall. 1994. ISBN 0-13-294844-3. £39.95. 451pp.
hardbound.

This isn't a book on any particular curricular subject in