Quantum Algorithms via Linear Algebra

computer science/mathematics

A PRIMER | RICHARD J. LIPTON AND KENNETH W. REGAN

This introduction to quantum algorithms is concise but comprehensive, covering many key algorithms. It is mathematically rigorous but requires minimal background and assumes no knowledge of quantum theory or quantum mechanics. The book explains quantum computation in terms of elementary linear algebra; it assumes the reader will have some familiarity with vectors, matrices, and their basic properties, but offers a review of all the relevant material from linear algebra. By emphasizing computation and algorithms rather than physics, this primer makes quantum algorithms accessible to students and researchers in computer science without the complications of quantum mechanical notation, physical concepts, and philosophical issues.

After explaining the development of quantum operations and computations based on linear algebra, the book presents the major quantum algorithms, from seminal algorithms by Deutsch, Jozsa, and Simon through Shor's and Grover's algorithms to recent quantum walks. It covers quantum gates, computational complexity, and some graph theory. Mathematical proofs are generally short and straightforward; quantum circuits and gates are used to illuminate linear algebra; and the discussion of complexity is anchored in computational problems rather than machine models.

Quantum Algorithms via Linear Algebra is suitable for classroom use or as a reference for computer scientists and mathematicians.

Richard J. Lipton is Professor and Frederick G. Storey Chair in Computing at Georgia Tech. Kenneth W. Regan is Associate Professor in the Department of Computer Science and Engineering at the University at Buffalo, State University of New York.

"A remarkably large part of quantum algorithms and quantum computing can be described with just the knowledge of multiplying matrices with complex number entries. Lipton and Regan have done a great job presenting all the major quantum algorithms from this easy and accessible point of view. Anyone interested in quantum computing would gain much from this presentation."
—Noson S. Yanofsky, Professor, Department of Computer and Information Sciences, Brooklyn College; coauthor of *Quantum Computing for Computer Scientists*

"This book gives an excellent, rigorous introduction to quantum computing, using only the mathematical background normal for an undergraduate computer science major. Students often ask me how they can get started toward understanding this field, and I can now point them to this book. I will certainly recommend it to all the students in my undergraduate theory of computation class."
—David Mix Barrington, School of Computer Science, University of Massachusetts Amherst

"*Quantum Algorithms via Linear Algebra* provides a great alternative introduction to the fascinating area of quantum computing. While traditional treatments are rooted in quantum mechanics, this quantum way of thinking could be a barrier for entry into this area. This book strips out the 'quantum-ness' from some famous algorithms and keeps it about elementary linear algebra, thus opening up quantum computing to a larger audience."
—Nisheeth Vishnoi, École Polytechnique Fédérale de Lausanne

"*Quantum Algorithms via Linear Algebra* is a marvelous and self-contained account of the algorithms that 'made' quantum computing, presented in a clear and conversational style that is a delight to read. It succeeds in giving a mathematically precise, and complete, exposition that invokes only elementary linear algebra. This style of presentation strips away unnecessary notation and abstraction and brings the beautiful ideas underlying these algorithms into a sharp focus."
—Chris Umans, Professor of Computer Science, Caltech

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