Making light work of computing

A lucid account of optical information-processing technology.

Mind at Light Speed: A New Kind of Intelligence
by David D. Nolte
Free Press: 2001. 320 pp. $26

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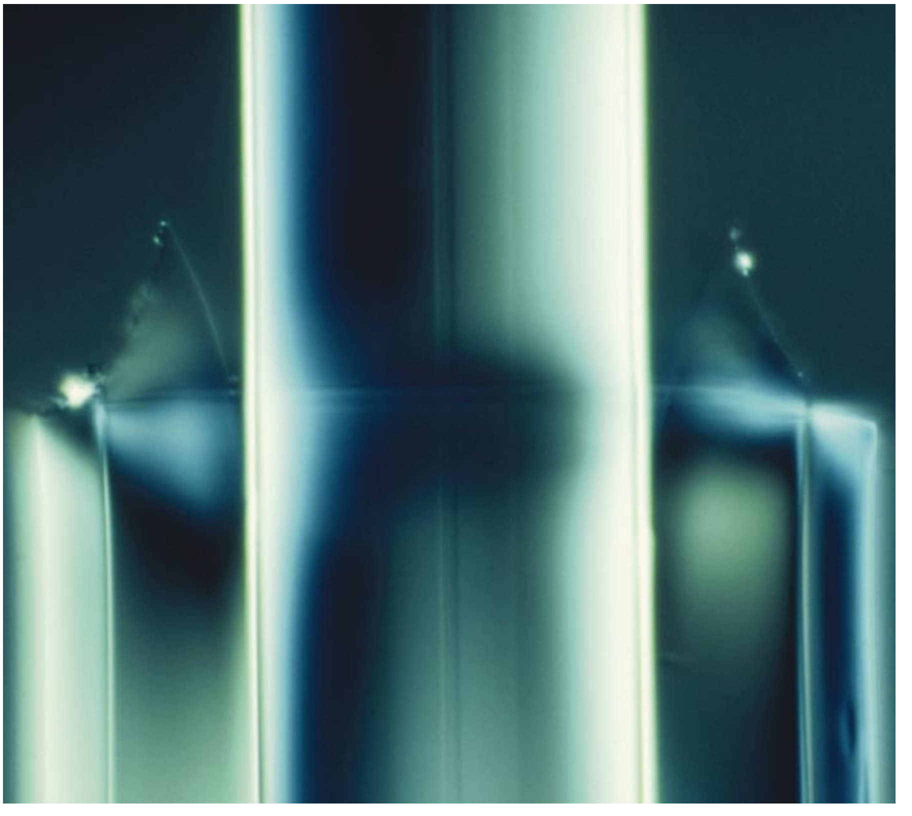

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Signal strength: fibre-optic technology has allowed vast quantities of data to be stored and transmitted.

As a professional scientist, it's never easy to explain to your mother what you do for a living unless she happens to be one too. So most of us find ourselves in the situation described by David Mermin in the preface to his book *Boojums All the Way Through* (Cambridge Univ. Press, 1990). The response to any explanation is invariably: "It's very impressive — I couldn't understand a single word."

Nolte's book is the antidote to such a dilemma. It's the sort of thing one could hand to a relative, even one not versed in university-level science, and expect them to be able to understand something of the field of optical information processing. The core of the book describes a hierarchy of optical networks: the optoelectronic, the photonic and the quantum. Nolte uses this structure as a hook on which to hang lucid explanations of the relevant technology for each, and its limitations.

To explain how information is processed, the book begins with some physiology and neuroscience, and even semiotics. Some of this is relevant to modern information technology: neuronal processing of sensory information has direct descendants in computational pattern recognition, for example. But it seems a stretch to claim that the rate of sensory information input is really a bottleneck to intelligence.

Nolte then goes on to explain how optics can dramatically increase the information capacity of a communications system, by combining the inherently large potential bandwidth of optical-frequency waves and the near inability of light to interact with itself in glass. Controlling (that is, sorting and routing) the optical data packets along the strands of glass that form the backbone of the current optical network requires particles that are not so benign. In optoelectronic systems these are electrons, but Nolte makes a convincing case that light can act as both Mercury and Apollo — messenger and diviner — through the development of new nonlinear optical materials.

The intensity-dependent response of optical detectors makes possible the final ingredient in classical optical information processing: holography. The description of this concept and its use in information storage is a delightful part of the book, and the back-of-the envelope calculations of the storage capacity of a holographic memory are something I would strongly recommend to most optics students. Nolte shows elegantly the idea of optimal encoding that leads to the massive parallelism that optics can provide.

The final section of the book concerns the much more futuristic technology based on information processing using quantum systems. The potential of such systems for secure communications and faster computations is harder to explain than the classical physics associated with the current and next generations of optical technologies. Some parts of this section are insightful. For instance, the notion that information does not exist in the quantum system until it is observed implies that the 'parallel processing advantage' of quantum interference and entanglement has a more subtle meaning than one might naively imagine.

But other parts of the book are rather misleading. For instance, the explanation of the Einstein–Podolsky–Rosen paradox almost misses the point entirely. Correlated particles that exhibit the same sort of nonlocality between distant measurements, as Nolte describes, exist in the classical world. It is the ability simultaneously to ascribe both a definite position and momentum to the second of two non-interacting particles, in apparent contravention of Heisenberg's uncertainty principle, that led Einstein, Podolsky and Rosen to posit that quantum mechanics did not satisfy the criteria expected of a physical theory.

The thesis that Nolte develops sporadically throughout the book — that optics is the route to intelligent machines — is perhaps overstated. But the fervour with which he describes it conveys the excitement engendered by working in cutting-edge science. Indeed, he seems as enchanted with his optical technology as the smitten Pygmalion with his creation Galatea.

If one overlooks the speculative excesses of the first and final chapters, Nolte has a remarkable ability to bring out the essential scientific features in a way that is both thought-provoking and pedagogical. He provides a fairly complete picture for the student and interested amateur of why the technology works the way it does, describes the roadblocks to improving system performance, and discusses the effects on telecommunications and data processing. You can always skip the teleology. ■

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