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Preface

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Light is the quintessential messenger. It travels faster than anything else can travel. It weighs nothing, and costs almost as little to make. A million rays of light carrying a thousand colors can travel along with each other or through each other without interacting, carrying data and commands between millions of locations. This is the parallelism of light, and it represents massive communication and computational power. With it, machines of light can do a million things at once.

Imagine if our eyes could tap into this immense power. Indeed, visual information is streaming into our eyes and hitting our retinas at a rate over a billion bits per second. The need to feed the information-hungry eyes is one of the principal forces driving the exponential growth of information carried by the optical Internet. The desire for ever more sophisticated visual content puts demands on the Internet that can be solved only by using the parallelism of light moving in transparent glass fibers.

The optical revolution that began at the end of the 20th century was launched by the human eye, but it will move far beyond serving simple human senses. The power of parallelism is the basis of whole new classes of machines of light. These will draw increasingly from parallelism to become ever faster. But faster intelligence is not a revolution -- it is just more of the same. The real revolution will come when all-optical intelligence distributes itself over optical networks with light controlling light. The parallelism of the network will combine with the parallelism of light to form a distributed optical intelligence with a multiplicity of interconnections and nodes that rival human minds.

This book is a journey. It begins with the oldest (yet the most sophisticated) machine of light -- the human eye. It ends by exploring the quantum optical computers that will be realized late in this new century. I introduce three generations of machines of light in Chapter 2. The first is the optoelectronic generation that we are using now, driving the optical Internet. The second generation is the all-optical generation when light will control light and images become the units of information. The third and last generation is the quantum optical generation when quantum effects that defy classical logic are used to transport (even teleport) quantum information and perform impossible computations in the wink of an eye.

What will these machines of light look like? How will they manipulate information? Will they have intelligence? These are some of the questions that I ask when exploring the structure of visual intelligence in Chapter 3. Optical computers of the second generation, for instance, draw from concepts of neural networks.

The neural networks of the human eye and brain are the most sophisticated image processing machines that we know. They provide the starting point for artificial optical machines, as well as a basis for comparison and contrast to see how well our machines are doing. Detecting spatial features in a crowded scene is one of the simplest things our eyes and mind can do, yet it is one of the most challenging problems to artificial intelligence. Why? Our neurons are so slow. Our rate of reading is millions of time slower than the processing rates of our simple PCs. How can such slow machines perform so well, if so slowly? These questions are explored through Chapters 4 and 5

Which raises a tantalizing question. What if machines of light could tap into the parallelism of light without being hampered by human limitations? This is the challenge of the three generations of the machines of light. The optoelectronic generation, driving the bandwidth explosion on the Internet, is described in Chapter 6, followed by the migration to optical intelligence, described in Chapter 7, when information as light controls light and intelligence on the Internet become distributed over more intelligent nodes than there are neurons in the human brain. What kind of intelligence will that represent?

To tap fully the parallelism of light requires images to become the units of information. What if the bit, a simple yes-no, is replaced by an entire image as the "unit" of information? In such machines, one image will tell another image what to do. Chapter 8 describes holographic machines that dream visually, and that store information optically inside brilliantly clear crystals.

At the apex of optical evolution is the quantum optical computer. Nothing you have ever experienced can prepare you for the astronomical shift that quantum technology represents. What will become possible when quantum neural networks connect together through quantum teleportation across the Quantum Internet? The entire network will become a single quantum wavefunction –- and our conscious minds will be plugged directly into it. Whose consciousness will the network have? Will it have our consciousness, or will we have its?

These are questions raised on our journey from hieroglyphics, the first optical programming language invented at the dawn of civilization, to holographic quantum computers of the next century. Plug in your eyes and enjoy the ride!