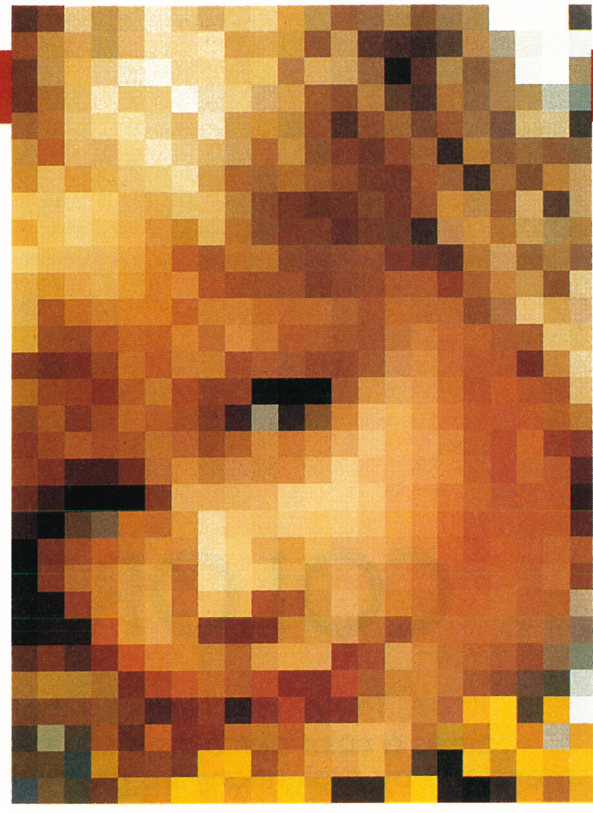
SPECIAL ISSUE

THE PHYSICS OF DIGITAL COLOR



Images have always been the best mode of communication between people, but technologies such as the typewriter have long made text easier to reproduce than images. As a result of two separate, but closely related, revolutions in technology, however, digital color images are now becoming commonplace. First, the practical use of digital technology in imaging could not have come about without the tremendous gains made over the past 20 years or so in the speed and capability of digital computers and peripherals, coupled with continuous reductions in cost for equivalent performance. Second, in the last few decades our understanding of the physics and chemistry underlying the technologies of scanning, displaying and printing color images has vastly improved; at the same time we have seen tremendous developments in related manufacturing techniques.

Most newspapers now include color, and many of the images they show were captured by electronic cameras, transmitted over phone lines and, often, processed digitally before being printed. The ever present TV, while still mostly analog, nevertheless displays more and more digital graphics, animation and other digital trickery every day. Unlike an analog system, a digital system offers the flexibility of altering an image at will. So much digital processing is done for magazines, especially their covers, that debates have begun about just what processing is ethical and what goes too far, distorting the images to the point where they violate standards of journalistic accuracy. Millions of amateurs own computers, most of which use color graphics, and some of them can manipulate digital images. The current electronic imaging market is many billions of dollars (the specific figure depends on how one measures it) and growing at about 50% each year.

The picture on this page illustrates some of the characteristics of digital images. A digital reproduction of some scene or object consists of rows of pixels, each of which shows the color sampled from the corresponding region of the original image. In practical use, there are hundreds or thousands of pixels per inch. Here, however, to show how pixels look, we have used only about 20 pixels across the whole picture, and we have shown each as a square block. If you hold the picture farther away than normal reading distance, you can simulate what happens as pixels are made smaller. You should be able to make out the face of a little girl. Printed on a typical color computer printer, 20 pixels occupy only $\frac{1}{20}$ of an inch, so practical digital images have millions of pixels, instead of the roughly 600 pixels in this illustration.

In this issue, five authors, each well known in his field, present state-of-the-art reviews of the various aspects of handling color images with digital systems. We start on page 24 with Alan Robertson's perspective on human color perception, for ultimately it is the visual system that gives us our sense of color. As Robertson writes, "Color is, first and foremost, a perception." For example, as you varied the viewing distance of the picture your perception changed from seeing brown blocks to seeing blonde hair with shadows. The article by Jan Allebach on page 32 describes how color information about the millions of pixels of a digital image is encoded for transmission throughout a digital color imaging system.

The last three articles cover the sensing, display and printing of color images. Rajinder Khosla (page 42) describes how semiconductor devices interact with light to record color images in electronic cameras and image scanners. Lawrence Tannas Jr (page 52) reviews the well-established technology of color cathode-ray tubes (like the one I am using to view this introduction as I type it) and then explains the inner workings of the various new flat-panel display technologies, which promise to change the way we think about color displays. Gary Starkweather (page 60) covers almost a century of developments in printing color images on paper. He concentrates on the new technologies for nonimpact printing, some of which will soon make color printing commonplace even on home computers. In these three articles, we learn the physics of making devices that are compact, relatively inexpensive and capable of handling the millions of pixels that make up every color digital image.

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