[American Photographer, Jan. 1989, invited paper.]

The Digital Darkroom

Today's technology brings digital imaging beyond photography

by Gerard J. Holzmann

The art of manipulating photographic images can be traced back to the early days of photography. There is little to indicate that a ''photographic reality'' ever existed.

Not long after photography was invented, photographers learned that they could perfect the new-found photographic perfection by such techniques as retouching, hand-coloring, or even combination printing. Of course, not everyone was please with this type of trickery. In 1856 already, a series of angry letters appeared in the Journal of the *London Photographic Society*, complaining about the manipulation of photographs. In particular, these protesters wanted retouched photographs banned from all exhibitions organized by the London Society. The campaign was to no avail. Much later, a photography historian wrote, ''... retouching had reached such proportions, it seems, that it became difficult to find photographs which had not been embellished by hand.''

As early as in 1859, the now familiar technique of double exposure was described in detail by the English photographer Henry Peach Robinson in a booklet with the revealing title *On Printing Photographic Pictures from Several Negatives*. The technique was also used in the late nineteenth century to ''prove'' the existence of ghosts. A pre-exposed plate would be used to photograph a scene, and the ghost would appear on cue when the plate was developed before an objective audience.

Photographic manipulations have been popular throughout the years, from Peach Robinson in 1859, and John Heartfield in the 1920's, to the perfect creations of, for instance, Jerry Uelsmann today. And now, there is a new tool for the darkroom, the computer.

If nearly every kind of image manipulation can be done, and has been done, in a regular darkroom, why would we even bother trying to use a computer? There are two main reasons. First, the changes you make in a digitized picture with a computer editor are always reversible, which makes it much easier to experiment with different types of transformations. Second, not only can the computer mimic with programs everything that a skilled professional can do in a darkroom with light and chemicals, it can also produce images that are nearly impossible to create in any other way.

How would you slowly fade a positive image into its negative, or twist an image into a perfect spiral? The changes can also be more subtle, of course. In the digital darkroom we can remove freckles and scars, or change the shape of a nose. Best of all, in a digital darkroom you never have to get your hands wet or turn off the light, unless you want to of course.

As an example of a digital image transformation, sixteen transformations from a demonstration program called ''Pinocchio'' illustrate this article. Doug McIlroy, my

department head at Bell Labs when I wrote the program, was the victim, and his children provided a very appreciative audience. The transformation can just as easily be reversed, as shown in the single photo. Anyone interested can find specific instructions on this and many other effects in my book *Beyond Photography — The Digital Darkroom*, published by Prentice Hall. The effects can be reproduced on any computer that runs the programming language C.

To manipulate an original photograph the image must first be digitized, i.e. translated into numbers, with a photographic scanner. Turning a continuous tone image into a set of numbers isn't new, it was first done in the 1920's with a system called the *Bartlane* cable picture system. The Bartlane system could transmit a photograph via a telephone cable from London to New York, in about three hours, with enough resolution to publish it in a newspaper. In the 1960's NASA used the same principle to transmit images taken by the *Ranger* and *Surveyor* spacecraft. Their system was of course much faster and allowed more detail to be transmitted.

Computers work with numbers, and can, in principle, handle any problem that can be translated into numbers. A photograph is just a large collection of dots, silver grains or dye spots, on a piece of film or paper. Each dot has a brightness, and perhaps a color. The brightness value of each color component can be assigned a number and stored in a computer. As long as the computer can keep track of which number corresponds to which location in the picture, it can always recreate the original image.

How many numbers does it take to define a photograph? The answer is surprising. Roughly 20 million numbers, each with a value between 0 and 255, are sufficient to record *all* the information present in a medium grain 35mm black and white negative. From the numbers we can always perfectly recreate the complete image from the negative, with losing any information. The information will not age or fade, and, since numbers are just numbers, they can be manipulated by a computer. Of course, for ordinary image processing we do not need quite that much information to work in a digital darkroom. About 200,000 numbers suffice in most cases to fool the human eye. The little pictures in the *Pinocchio* illustration have even less information: about 16,000 numbers per picture.

It is not unlikely that within the next 10 years the cameras we use today will be replaced with digital cameras. Some off the major photo-camera producers have, in fact, already made proto-types (including Canon, Kodak, and Sony). These digital cameras take photos not on conventional film but on a computer-like floppy disc. The disc is processed in a computer, with the type of software that I describe in my book. So far, the floppy disc that the proto-type cameras have been standardized on stores photos at video resolution. they can be displayed on a television screen and printed on specially made film printers. Someday, these photo disc readers and digital film printers may be as standard on a personal computer as the matrix printer is today.

The development of the digital SLR camera first became possible with the invention of the charge-coupled device (CCD) by Willard S. Boyle and George E. Smith at Bell Labs. The CCD, patented in the early 1970's, is a computer chip that works like a tiny pack of photocells. Each cell translates brightness values via electrical signals into numbers. Thousands, and sometimes millions, of these CCD elements are packed onto a single chip, which can grab and digitize complete images at a time.

A truly high-resolution digital SLR camera is yet to be built, but the low resolution alternatives are available today. Canon makes a camera called the RC-701, and Sony sells the Mavica camera. Both have comparable performance. The photo discs they use are made by Kodak, and they are interchangeable. The discs used so far store images in video format, rather than in digital code. This limits the resolution of the first generation of cameras to about 500x500 dots, a far cry from the resolution of conventional film of roughly 4000x4000 dots. To become a viable alternative to conventional photography, therefore the resolution of the new cameras will have to go up, at least by a factor of five. And, for that matter, their price will have to go down by about the same factor.

The original photographs used in the experiments illustrated in this article were digitized on a $30,000 scanner made by Imagitex Inc., in Nashua, New York. The digitized image was then manipulated on a DEC/VAX-750 computer (DEC and VAX are trademarks of Digital Equipment Corp.) and the modified photos were output on a $20,000 film printer made by Matrix Instruments Inc., in Orangeburg, New York. The Matrix QCR D4/2 unit can recreate a digitized image in color on 8x10 sheet film in approximately 20 minutes and has a maximum resolution of 4096x4096 dots. There are, of course, many other, lower-cost digital scanners, computers and printers available.

The future of the use of digital image processing techniques in photography looks very bright indeed. There are applications in art, industrial and commercial photography, and in amateur photography. Our idea of what photography is all about may be forever transformed.

This article is an excerpt and a condensation of two chapters from the book *Beyond Photography — The Digital Darkroom*, by Gerard J. Holzmann, ISBN 0-13-074410-7, $29.95, Prentice Hall, Englewood Cliffs, NJ 07632.

The book can be ordered through any local bookstore or directly from the Book Distribution Center, Prentice Hall Inc., Route 59 at Brook Hill Drive, West Nyack, NY 10995.

Biography

Gerard J. Holzmann is a photographer, and a researcher at AT&T Bell Laboratories, in Murray Hill, New Jersey. He holds an M.Sc. in Electrical Engineering and a Ph.D. in the Technical Sciences, both from Delft University in The Netherlands.