Digital Images

Computer Sciences

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A digital image (/science-and-technology/computers-and-electrical-engineering/computers-and-computing/digital-image) is a representation of a real image as a set of numbers that can be stored and handled by a digital computer (/science-and-technology/computers-and-electrical-engineering/computers-and-computing/digital). In order to translate the image into numbers, it is divided into small areas called **pixels** (picture elements). For each pixel, the imaging device records a number, or a small set of numbers, that describe some property of this pixel, such as its brightness (the intensity of the light) or its color. The numbers are arranged in an array of rows and columns that correspond to the vertical and horizontal positions of the pixels in the image.

Digital images have several basic characteristics. One is the *type* of the image. For example, a black and white image records only the intensity of the light falling on the pixels. A color image can have three colors, normally RGB (Red, Green, Blue) or four colors, CMYK (Cyan, Magenta, Yellow, blacK). RGB images are usually used in computer monitors and scanners, while CMYK images are used in color printers. There are also non-optical images such as ultrasound or X-ray in which the intensity of sound or X-rays is recorded. In range images, the distance of the pixel from the observer is recorded. *Resolution* is expressed in the number of pixels per inch (ppi). A higher resolution gives a more detailed image. A computer monitor typically has a resolution of 100 ppi, while a printer has a resolution ranging from 300 ppi to more than 1440 ppi. This is why an image looks much better in print than on a monitor.

The *color depth* (of a color image) or "bits per pixel" is the number of **bits** in the numbers that describe the brightness or the color. More bits make it possible to record more shades of gray or more colors. For example, an RGB image with 8 bits per color has a total of 24 bits per pixel ("true color"). Each bit can represent two possible colors so we get a total of 16,777,216 possible colors. A typical **GIF image** on a web page has 8 bits for all colors combined for a total of 256 colors. However, it is a much smaller image than a 24 bit one so it downloads more quickly. A fax image has only one bit or two "colors," black and white. The *format* of the image gives more details about how the numbers are arranged in the image file, including what kind of compression is used, if any. Among the most popular of the dozens of formats available are TIFF, GIF, JPEG, PNG, and Post-Script.

Digital images tend to produce big files and are often compressed to make the files smaller. *Compression* takes advantage of the fact that many nearby pixels in the image have similar colors or brightness. Instead of recording each pixel separately, one can record that, for example, "the 100 pixels around a certain position are all white." Compression methods vary in their efficiency and speed. The GIF method has good compression for 8 bit pictures, while the **JPEG** is **lossy** , i.e. it causes some image degradation. JPEG's advantage is speed, so it is suitable for motion pictures (/literature-and-arts/performing-arts/film-and-television/motion-pictures).

One of the advantages of digital images over traditional ones is the ability to transfer them electronically almost instantaneously and convert them easily from one medium to another such as from a web page to a computer screen to a printer. A bigger advantage is the ability to change them according to one's needs. There are several programs available now which give a user the ability to do that, including Photoshop, Photopaint, and the Gimp. With such a program, a user can change the colors and brightness of an image, delete unwanted visible objects, move others, and merge objects from several images, among many other operations. In this way a user can retouch family photos or even create new images. Other software, such as word processors and desktop publishing (/science-and-technology/computers-and-electrical-engineering/computers-and-computing/desktop) programs, can easily combine digital images with text to produce books or magazines much more efficiently than with traditional methods.

A very promising use of digital images is automatic object recognition. In this application, a computer can automatically recognize an object shown in the image and identify it by name. One of the most important uses of this is in **robotics** . A robot can be equipped with digital cameras that can serve as its "eyes" and produce images. If the robot could recognize an object in these images, then it could make use of it. For instance, in a factory environment, the robot could use a screwdriver in the

assembly of products. For this task, it has to recognize both the screwdriver and the various parts of the product. At home a robot could recognize objects to be cleaned. Other promising applications are in medicine, for example, in finding tumors in X-ray images. Security equipment could recognize the faces of people ap proaching a building. Automated drivers could drive a car without human intervention or drive a vehicle in inhospitable environments such as on the planet Mars or in a battlefield.

To recognize an object, the computer has to compare the image to a database of objects in its memory. This is a simple task for humans but it has proven to be very difficult to do automatically. One reason is that an object rarely produces the same image of itself. An object can be seen from many different viewpoints and under different lighting conditions, and each such variation will produce an image that looks different to the computer. The object itself can also change; for instance, a smiling face looks different from a serious face of the same person. Because of these difficulties, research in this field has been rather slow, but there are already successes in limited areas such as inspection of products on assembly lines, fingerprint identification by the FBI (/social-sciences-and-law/political-science-and-government/us-government/federal-bureau-investigation), and optical character recognition (/science-and-technology/computers-and-electrical-engineering/computers-and-computing/optical) (OCR). OCR is now used by the U.S. Postal Service to read printed addresses and automatically direct the letters to their destination, and by scanning software to convert printed text to computer readable text.

See also Art; Digital Libraries; Fashion Design; Optical Technology; Photography.

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