

Consumer Digital Photography: The Big Picture

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Abstract

Consumer electronic imaging began with the development of home video camcorders. Camcorder technologies enabled the creation of the first electronic still cameras, using the still video floppy (SVF) standard. This allowed still pictures to be captured, stored, displayed, and printed, but only within the constraints of NTSC or PAL television standards and components. Digital photography was enabled by the personal computer. Computer technologies allow images to be stored on many different digital media. Unlike an SVF disk, the computer does not force the image signal through a limited bandwidth channel, so digital images can offer a wide range of quality levels.

The basement home darkroom has moved to the den, and become a "desktop digital darkroom". Instead of using chemicals, it's based on powerful multimedia computers, creative software applications, inexpensive memory, affordable scanners, digital cameras, and color printers. But consumer digital photography doesn't stop at the home. Connections to retail stores, and to service providers such as photofinishers, provide high quality, cost-effective ways to digitize, print, or transmit defacto images. These systems provide many options for creating and sharing personal images with family and friends at home and around the world.

1. Consumer Imaging History

As IS&T celebrates its 50th anniversary this year, it is interesting to look back at the history of consumer imaging, to review where digital photography is today, and to consider what the future may hold. Figure 1 shows some of the milestones on the path to consumer digital photography. It was just over 150 years ago that Daguerre discovered a method to "fix" the image formed in the focal plane of a camera lens.[1] For the next 50 years, consumer photography meant sitting very still during portraits taken by skilled photographers onto glass plates coated with light-sensitive emulsions.

Consumers first became photographers about 100 years ago, with the introduction of simple-to-use cameras employing flexible film. Just as with today's single-use cameras, the camera containing exposed consumer film was returned to a retailer, who sent it to a photofinisher for development and printing. An important milestone was reached by hiding the difficult aspects of photography from the consumer, who simply had to push a button at the proper instant. Color was added to consumer photography about 50 years ago. While the color films could be used with existing consumer cameras, the design and calibration of both the film stock and the photofinishing system was critical to obtaining high-quality color prints.

Evolution of Photography

t-150	Glass Plates	1847
t-100	Flexible Film	1897
t-50	Color Photography	1947
t-25	Video Photography	1972
t-15	Home Video/Still Video	1982
t-5	Digital	1992
t-0	Consumer Digital	1997
t++	The Net: Decentralized Digital Photography — What Would You Like to Where Would You Like to Do	21st Century

Figure 1.

2. Analog Electronic Photography

Consumer electronic imaging began about 25 years ago, with the development of home video cameras using vacuum tube sensors. The focus was motion imaging centric, tied to the existing television standards. As technology developed, tubes were replaced by CCD imagers, and electronics were integrated in custom ICs. TV cameras and video recorders shrunk in size, so capture and recording functions could be combined in miniature camcorders. About 15 years ago, camcorder technologies enabled the creation of analog electronic still cameras,2 with a new variation of magnetic media, the still video floppy (SVF). This allowed still pictures to be captured, transmitted, displayed, and printed, as shown in Figure 2. However, since the analog SVF system was used to store the image, the resolution and signal-to-noise ratio were very limited. Instead of a single, worldwide format, there were different recording formats based on the NTSC and PAL television standards.

3. Digital Photography

Digital photography has grown rapidly in the last five years, enabled by the latent personal computer. Digital computer technology allows images to be stored on many different

digital media, such as floppy disks, optical disks, magnetic hard drives, and Flash EPROM memory cards. Images can viewed on high resolution, progressive scan, square pixel displays. Home computers enable consumers to easily edit and use their images for everything from greeting cards to personal home pages on the world wide web. Unlike an SVF disk, the computer does not force the image format to match the constraints of the NTSC or PAL TV standards, so digital photography can offer a wide range of quality levels.

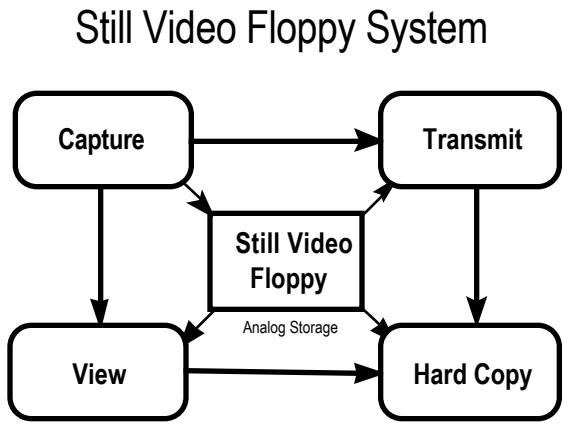

Figure 2

Consumer digital photography systems can utilize equipment and services located in the consumer's home, and at retail and photofinisher sites, as shown Figure 3. In the home, consumers who have the expertise and income to buy an image-capable computer can use their home PC as a "digital darkroom". Applications such as Microsoft PictureIt! software allow personal digital images from many sources to be incorporated into collages, greeting cards, invitations, and calendars. These images can be printed at home, or the digital files can be mailed or electronically transferred to a photofinisher for printing, for example using the *Kodak Image Magic* Print Service. Consumer digital images can be incorporated into electronic postcards albums, and slide shows that can be shared with others using software such as the *Kodak Digital Science* Picture Postcard software, or services such as the *Kodak* Picture Network.

Even consumers who don't care to use computers can enjoy the benefits of digital photography equipment located at retail and photofinishing sites. The *Kodak Image Magic* CopyPrint Station, installed at retail counters in many stores, is one example. This system allows photographic prints to be duplicated, using a high-quality sublimation dye transfer printer. Creative borders can be added, and damaged prints can be restored. A second example is the digital high-speed scanners and CRT printers, installed at photofinishers, used to generate index prints. Consumers can order an index print when their film is developed. This digital index print allows the consumer to more easily catalog their film negatives, and order reprints.

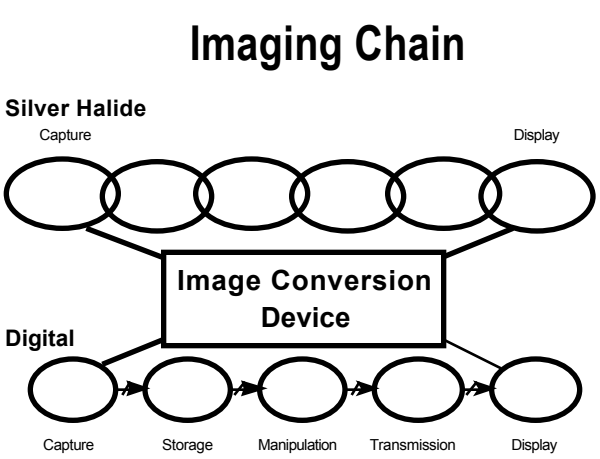

Figure 3.

4. Digital Imaging Chains

Digital photography systems use digital devices to implement some, or all, of the imaging chain,[3] shown in Figure 4. The images may be captured with a digital camera, such as the *Kodak Digital Science* DC25 Camera, or with a conventional film or instant print camera. In the latter cases, the developed film or prints are scanned to provide image conversion to the digital domain. This conversion can be done using a home scanner, for example the *Kodak Digital Science* Snapshot Photo Scanner 1. Alternately, the consumer can have their images scanned by a retailer or photofinisher. At the retailer, for example, the *Kodak Image Magic* Enhancement Station 100 can scan a print and store the digital image on a floppy disk. Alternately, film negatives can be scanned using the *Kodak PCD* Imaging Workstation, and stored on a CD-R recordable optical disk. The latter offers the highest quality digital record, but requires more costly equipment.

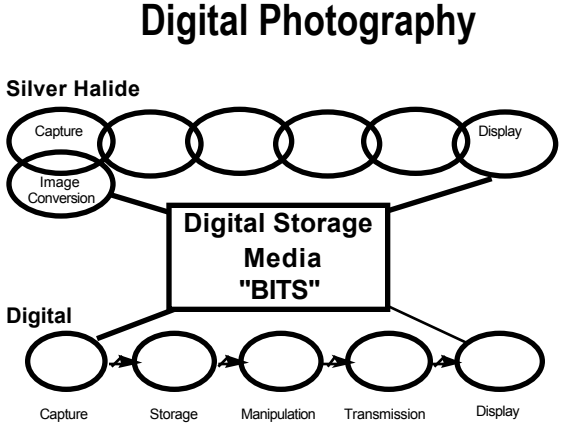

Figure 4.

5. Digital Image Formats

In conventional photography, the photographic negative is the heart of the imaging system. It not only captures and

stores the image, it also serves as the "standard" interface format between the consumer, retailer, and photofinisher. Both consumer cameras and photofinishing equipment are standardized around the film width and perforations, and the film processing chemistry.

Figure 5 shows that the heart of a digital photography system is the digital image format, rather than the physical media that stores the digital image. Different physical media, such as Flash EPROM cards, magnetic hard drives, and CD-R optical disks may store the same digital image data at different points in the imaging chain. But it is the "bits" that comprise the digital image, and not the "atoms" of any particular type of digital storage device, that are essential to digital imaging.[4] The important bits include not only the digital image data, but also "ancillary" information such as the date the image was taken, the copyright owner, the scene light level and subject distance, and data that characterizes the image capture device. This ancillary information may also include a digital audio recording, and connections to other images that form a motion sequence.

Numerous proprietary and standard image formats have been used in digital photography systems. The most popular formats for compressed images, such as Exif and JFIF, utilize the JPEG interchange format with special application markers to store limited ancillary information. In comparison, the recently developed FlashPix file format[5] offers numerous advantages as the preferred image format for digital photography systems. The tiled, hierarchical image representation used in FlashPix enables applications to quickly provide appropriately sized image information for display or printing. Calibrated *PhotoYCC* and RGB color interchange spaces enable color information to be conveyed in an unambiguous manner. The use of structured storage allows a FlashPix file to be edited by applications, not just used for interchanging images between devices. Structured storage also allows the ancillary information to be easily searched to locate images having the desired attributes.

6. Future Consumer Digital Photography Trends

What will consumer digital photography be like five or ten years from now? While predictions are always problematic, there are some likely trends worth mentioning:

- The importance of networks will continue to grow, as shown in Figure 6. High speed fixed and mobile network connections will make it easy to electronically transfer and access your personal images in your home, at the office, and on the go.
- The same computer technology that provides today's powerful desktop digital darkrooms could be "hidden" in programmable, easy-to-use camera digital assistants.

Today, consumer still and motion image capture is done with separate still cameras and video camcorders. In the future, a single motion/still camera might be used to capture both types of images on the same digital storage media.

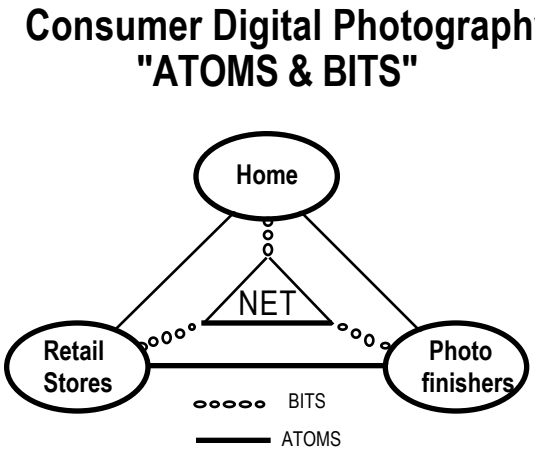

Figure 5

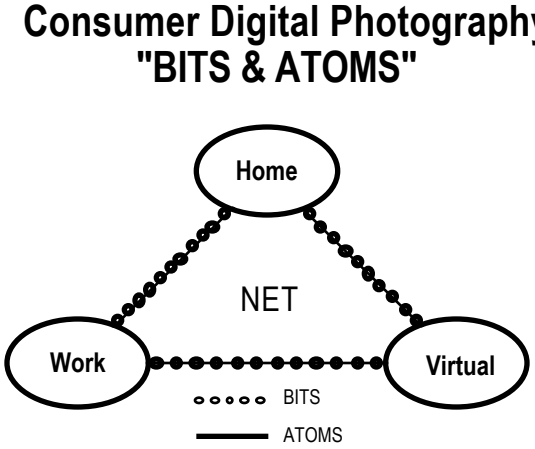

Figure 6

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