

Hybrid Imaging Systems

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Abstract

As personal computers become popular, the demands for digital images with photographic quality on a desktop grow in the consumer market. Hybrid imaging system meet the demand for digital imaging by joining conventional silver halide image capture with digital image access, processing, and storage. The rationale for, features of, and demands on hybrid imaging systems are explored.

Introduction

Today's proliferation of personal computers has brought a booming demand for efficient image access, processing, storage, and transfer. Indeed, there are fully digital imaging systems how attempting to meet the demand, but they suffer from one especially weak link: the quality of image capture. For example, to match the information-carrying of a 35mm color negative film frame, a digital image of at least 1 million pixels is needed.[1] While some high-end digital cameras do meet this minimum, they are prohibitively expensive. In contrast, consumer grade digital cameras are affordable, but they provide images of only about 0.3 million pixels, while their image quality further suffers because of the image interpolation necessitiated by these single CCD cameras.

The answer to this situation has been hybrid imaging. In a hybrid imaging system, image capture takes place on silver halide film which is then processed, scanned, and digitized. Thus, hybrid imaging systems combine analog and digital imaging to reap the advantages of both.

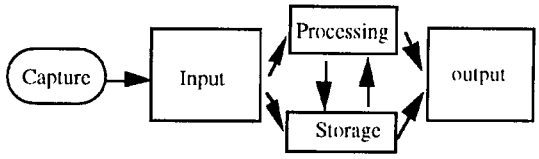

Figure 1. Diagram of hybrid imaging system

As seen in Figure 1, hybrid imaging systems entail five functions: capture, input, processing, storage, and output. Image capture through conventional photography is the analog component of a hybrid imaging system, while the remaining functions constitute the digital component. Since the features of conventional image capture are well known, we will focus on the digital component of a hybrid system, drawing examples from three systems available today: Fuji's FRONTIER, Eastman Kodak's PhotoCD, and Konica's Picture MD.

Demands on Hybrid Imaging Systems

The digital component of a hybrid system must provide four general capabilities: high quality image input and output, optimum color conversion, powerful image processing, and efficient image data handling.

1. High Quality Image Input and Output

Visible images are the beginning and end of any photographic system, so high quality image input and output is essential to a hybrid imaging system. Within the limits of cost, input and output devices must maximize accuracy and minimize data loss.

Input Devices

Table 1 compares the input of a typical consumer-grade digital camera with the inputs of the film scanners employed in the three hybrid imaging systems mentioned earlier. Note that the digital camera does not even provide a third of the 1 million-pixel minimum noted earlier. In such cameras, image quality suffers from the cameras' single CCD and color filter arrays, from image artifacts caused by differing RGB resolutions, and from resolutions that are substantially below pixel correspondence. In contrast, the film scanners used in the three hybrid systems provide pixel counts well above minimum. While these film scanners differ in pixel count and in additional measures of performance (e.g. in lower noise, which does not always correspond to higher pixel count), all three provide high-quality conversion of analog to digital images.

Table 1. Input Devices

	Digital camera	FRONTIER	Photo CD	Picture MD
Image Size (pixels)	307200 (640x480)	1269600 (1380x920)	6291456 (3072x2048)	1572864 (1536x1024)
Scanning method	Area color CCD, signle CCD	Area color CCD	3-line color CCD	3-line color CCD

Output Devices

Table 2 compares several types of output device in order to reflect common choices made by system users. While

their performance in such terms as resolution and noise presents a tradeoff against cost. Improvements in image quality continue to be made especially in inkjet printer, and each of these devices has found its application niche.

2. Optimum Color Conversion from Nega to CRT/Printer

Optimum color conversion is crucial to image quality, and is based on a value judgment made when designing the system. For example, the PhotoCD system seeks the accurate reproduction of the actual colors of a photographed scene. In contrast, the Picture MD system targets colors as they would appear in a color print from a color negative. Based on our surveys showing that consumers prefer over true colors, the color is adjusted through subjective test and contrast and saturation are raised to meet this color reproduction target.

Table 2. Output Devices

	Pictrography 3000	KONICA CRT PRINTER	EPSON MJ700-V2C	EPSON PM700C
Printing method	Silver halide laser	CRT expose	Ink Jet	Ink Jet
Resolution (dpi)	133-400	150	180, 360, 720	180, 360, 720
Quantization Levels	CMY 256, respectively	CMY 256, respectively	CMYK 2, respectively	C 3; M 3 Y 2; K 2
Max. file size (pixels)	4709 x 3431	1792 x 1280	7965 x5952 *1	7965x5952 *2
Pringint time	120 secs	20 secs	450 secs	240 secs

* 1, *2; printing time is calculated from resolution.

3. Powerful Image Editing

One of the strongest attractions of hybrid systems is the powerful image editing capability that they offer. In analog system, photographic image has to be manipulated in dark room, on the other hand, in hybrid imaging system, similar manipulation can be done on the computer easily. Everything that can be done conventionally—and much that cannot—can be done through digital image editing. Examples include Fuji FRONTlER's back lighting correction, high contrast correction, underexposure correction, and edge enhancement; Eastman Kodak PhotoCD's image cropping, automatic color balance adjustment, and semi-automatic dust and scratch removal; and Konica Picture MD's chroma and CMY density control, sharpness enhancement, cropping and scaling, rotating and flipping, superimposition, and special effects such as posterizing, mosaic, and sepia. And various kinds of software which manipulate photographic image have been developed.

4. Efficient Image Data Handling

To achieve the benefits of digital imaging, efficient image data handling is essential. Efficient image data handling is achieved chiefly through the selection of file formats, image file compression methods, and data storage devices. In combination, these technologies affect how well data can be stored, accessed, and transferred.

File Formats

File formats greatly affect data access and transfer, and there are advantages and disadvantages to the file formats currently adopted by various hybrid imaging systems. For example, the accessibility of a file depends on file format compatibility, so mutually exclusive proprietary file formats present a barrier to accessibility. At the same time, the multi-resolution approach that each of these file formats takes makes data transfer more practical, for example, by providing the means for a user to select optimum viewing resolution. In digital camera, file formats supporting compression image and noncompression image have been standardized[3,4].

Compression Methods

Compression methods also affect data transfer, but perhaps the most salient effects are on data loss and storage. Lossy compression methods such as JPEG, used in Konica's Picture MD, can lose some image data, though this is usually acceptable to users who value high compression ratio and correspondingly higher storage capacity. In contrast, the nealy lossless proprietary compression method used in Eastman Kodak's PhotoCD system has an advantage in lower data loss, but at the expense of a lower compression ratio.

Storage Devices

Finally, storage devices themselves affect access speed and storage capacity. The CD-ROMs, MOs, and MDs available for use in hybrid imaging systems are all high-capacity storage media, though the rough tradeoff here is with access speed. Great interest is being shown the upcoming DVDs, which will soon be rewritealbe and offer good speed with greatly expanded storage capacity.

Summary

To meet today's demands for digital imaging, hybrid imaging systems compensate for digital imaging's weak link of image capture by joining conventional silver halide image capture with digital image processing, storage, and transfer. Hybrid imaging systems' digital functions—input, processing, storage, output—demand high quality image input and output, optimum color conversion, powerful image processing, and efficient image data handling.

References

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