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Critical technologies for electronic still imaging systems

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ABSTRACT

Electronic still camera systems are now in the consumer market place. The hard copy image quality of these systems is poor in comparison with the ever improving photographic film systems. However, the rate at which solid state image sensor technology, signal processing technology, mass storage technology, and non–photographic hard copy technology are advancing indicates that these electronic still camera imaging systems will someday find a place alongside traditional photographic systems. The current and future status of these critical technologies is the subject of this paper.

1. INTRODUCTION

On January 6, 1839, the Academie des Science in Paris announced that Louis Jacques Mande Daguerre had "discovered a method to fix the images which were represented at the back of a camera obscura; ...".[1] Since that eventful day photographic images have dominated how mankind has recorded history from world wars to family outings and documented new discoveries ranging from the exploration of the atom and the tombs of ancient Egypt to the natural habitats of the rain forests, jungles, and deserts around the world. Before World War II there were no serious challenges to the photographic method of image recording, but the commercial development of color television in the 1950's and the subsequent development of high quality magnetic recording and VLSI semi–conductor technology in the 1970's and 1980's has brought electronic image recording to the consumer in the form of home video systems. The new 8 mm video camcorders have replaced the Super 8 film systems as the choice for recording family events and travel. In the commercial area, Electronic News Gathering, ENG, has replaced 16 mm film for television news broadcasting. Attempts are being made to use High Definition Television Systems (HDTV) as a replacement for film in the motion picture industry. While HDTV systems have not replaced film for motion picture production, the introduction of the BETA and VHS VCR systems and the Laser Disc systems have brought film originated movies into the homes of millions.

During the same time span, conventional silver halide–based still photography has had strong, continuous growth. This growth has been spurred by improvements in film, cameras and ease of processing. Today a consumer can spend less than $100 for a high quality 35 mm camera with autofocus, automatic exposure control, automatic film advance, automatic film speed indexing, and built–in electronic flash. The resulting images are of very high quality. But while conventional photography continues to enjoy strong growth there is another electronic imaging system appearing on the horizon, one that may someday share the consumer market with the film–based systems of today. The electronic still camera, ESC, is a commercial reality today, and it and the technologies that make it possible are the subject of this paper.

1.1 Electronic still camera system concept

Figure 1 shows a conceptual ESC system that could be assembled from currently available products. The system and camera is built around the Still Video Floppy, SVF, which records the image as an analog video signal.[2] Figure 2 shows the original SVF standard along with the new High–Band standard. In both cases the camera records 50 single field images or 25 full frame images; a video frame is made up of two interlaced fields. In the case of the High–Band standard, the images are recorded using a higher carrier frequency thus providing more bandwidth for each scan line and yielding greater horizontal resolution; the vertical resolution remains the same– 242 lines for the field format and 484 lines for the frame format.

The player/recorder converts the SVF analog signal into a form suitable for display on a conventional television set or monitor and also allows one to capture images from broadcast television or from VCR's and record them on the SVF disks. By using an image transceiver with a modem and public or private telephone communication systems one can send images anywhere in the world. Hard copy can be obtained from images stored on the SVF disks. The prints can be made from any number of print engines including thermal printers, electrophotographic printers, ink jet printers, and raster printers exposing conventional or instant photographic materials.

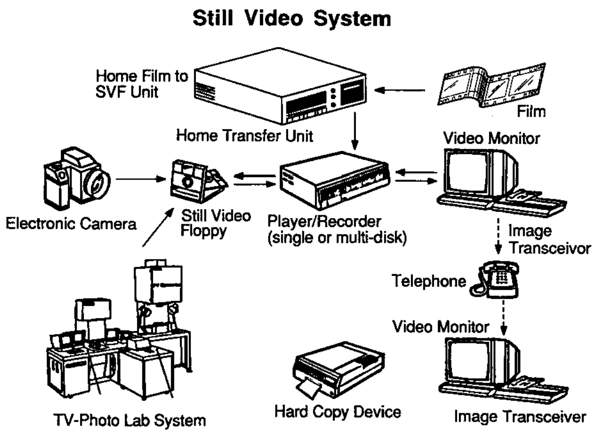

Figure 1. Conceptual diagram of a possible still video system based on the still video floppy, SVF, standard.

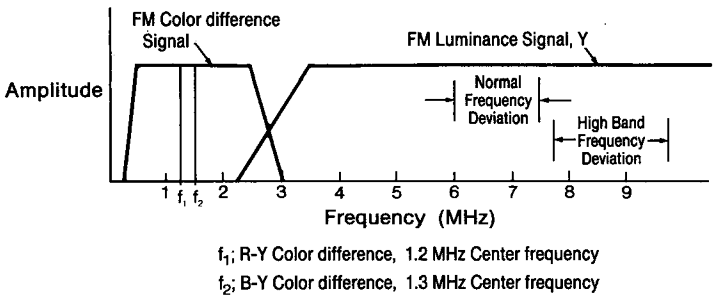

Figure 2. The image encoding standard for SVF systems.

An additional feature of the system is that a scanner can be used to convert existing images on negatives, transparencies, or paper into electronic signals for recording on the SVF disks. Image scanners/recorders can be installed either at photofinishers or in the home. Such a system provides complete flexibility to the consumer.

Figure 3 provides a more detailed look at the important parts of a ESC system; the system shown is just an abstraction of an ESC system and does not represent any particular product. One key aspect of such a system is that film–based images that are scanned into it can make use of the same system hardware and software that is used to transform the electronically captured image into a final hard copy print, soft display, or transmitted image.

In what follows, detailed discussions will be presented on the key ESC technologies: the solid state sensors that record the image, the in–camera signal processing that is required, the recording technology that stores the images, and the hard copy technology that produces prints. In far less detail, the technologies that deal with data compression and image manipulation will be discussed; the brevity of the discussions are not meant to imply that the technologies are not important, but that the detail required to fully understand the technologies falls beyond the scope of this paper.

As a final and very significant part of understanding an ESC system, the impact of international standards will be discussed. One of the key issues is the need for a world–wide, digital, non–broadcast television–based family of standards for future ESC systems.

In most of what follows, the emphasis will be directed toward systems that use hard copy output rather than soft display. The reason for this bias is based on the authors' feelings that an ESC system must produce hard copy images equivalent in quality to photographic prints. Many ESC images will be viewed via electronic displays, but current electronic display technology does not equal the photographic print or projected transparency for overall quality. Our crystal ball does not show us what display technology will hold sway in the future, so we, along with you, will have to watch the drama unfold before us.

1.2 Milestones in ESC systems [3,4,5]

Table 1 shows a complete list of ESCs that have been developed to date. A few of them rate special recognition from the historical point of view. In 1981 Sony demonstrated its Mavica color still camera and viewer, Mavipak transmitter, and Mavigraph video printer. The camera had a 280,000 pixel CCD sensor with red, green, and cyan stripes and the printer used thermal dye transfer technology with a 512–element heater. In 1986 Canon began marketing its RC 701 ESC system in the U.S. The camera used a CCD sensor with 380,000 pixels. In 1988 Canon introduced a high resolution version of its ESC, RC 760, with a CCD sensor that has 600,000 pixels. Also in 1988 Fuji Photo Ltd. demonstrated its 400,000 pixel ESC, DS–1P, that employed a removable static, random access memory, S–RAM card as the storage medium rather than the SVF disk. Polaroid demonstrated a monochrome ESC/motion camera which recorded still images on S–VHS–compact cassettes. The other ESC systems use the SVF disks for image storage. As can be seen from Table 1, the number of product entries are growing at a very rapid rate.

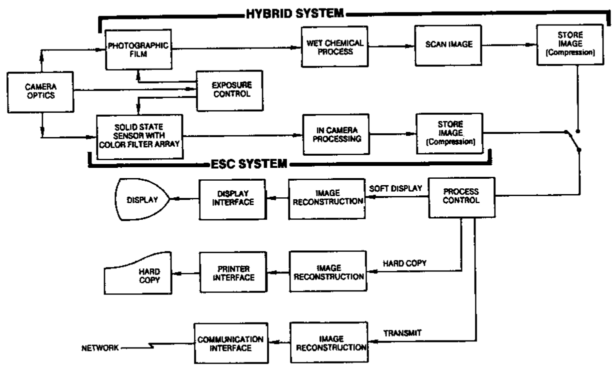

Figure 3. Functional outline of a hybrid imaging system and an electronic still camera system.

Electronic Still Camera

DATE	MODEL	MEDIA	IMAGER	LENS	COMMENTS
Aug 1981	Sony Mavica	Mavica	2/3" 280K	16-64mm	First ESC demo
Dec 1983	Toshiba	disc	2/3" 200K		64mm disc
July 1984	Canon	SVF	2/3 " 400K	16-64mm	Demo Camera
Oct 1984	Copal CV-1	SVF	2/3 " 280K	9-27mm	Demo Camera
Nov 1984	Hitachi	SVF	2/3" 190K		Demo Camera
Nov 1984	Panasonic	SVG	2/3" 300K	14-24mm,f/2	Demo Camera
Oct 1985	Sanyo	SVF	2/3" 280K	9-27mm	Demo Camera
Oct 1985	Mitsubishi	SVF			Demo Camera
May 1986	Canon RC 701	SVF	2/3" 380K	11-66mm	First ESC sold in US
Sept 1986	Panosonic 3100	SVF	2/3" 300K	10&25mm, AF	
Nov 1986	Chinon	SVF	2/3" 250K	12-72mm,f/1.7	Demo Camera
Dec 1986	Casio VS-101	SVF	2/3" 280K	11mm f/2.8	
Feb 1987	Rollei	SVF			Camera back for 3001/3
May 1987	Sony MVC-A7AF	SVF	2/3" 380K	12-72mm	
June 1987	Konica KC 400	SVF	2/3" 300K	12-36mm,AF	
June 1987	Kodak	SVF	2/3" 280K		Demo Camera
Sept 1987	Fuji ES-1	SVF	2/3" 380K	x3 Zoom	
Nov 1987	Minolta SB-90	SVF	2/3" 380K		Maxxum camera back
Jan 1988	Konica KC 100	SVF	2/3" 300K	11mm f/2.8	Binocular style
Jan 1988	Chinon	SVF			CP-9AF Camera back
Mar 1988	Canon RC 760	SVF	2/3" 600K		
Sept 1988	Nikon QV-1000C	SVF	2/3" 380K	x4/x11 Zoom	B/W Photojournalism
Sept 1988	Fuji ES20	Hi-SVF	2/3" 400K	12-25mm, AF	$1400 list price
Sept 1988	Canon Q-PIC	Hi-SVF	1/2" 360K	11mm f/2.8	$700 list price
Sept 1988	Olympus V-100	Hi-SVF	1/2" 360K	x3 Zoom f/2.8	Binocular style
Oct 1988	Konica KC300	Hi-SVF	1/2" 300K	12mm f/2.8	$700 list price
Oct 1988	Matsushita ES10	Hi-SVF	1/2" 360K	tele-wide	Commercial use ($2050)
Oct 1988	Sony 2MVC-C1	Hi-SVF	1/2" 280K	auto focus	$650 list price
Oct 1988	Canon RC-470	Hi-SVF	1/2" 360K	9&16mm	Business use (1950)
→ Oct 1988	Fuji DS-1P	RAM	2/3" 400K	16mm	16 MByte RAM card
Oct 1988	Polaroid S/V-M	S-VHS	2/3" 550K	12mm f/1.3	B/W still & Motion
Nov 1988	Minolta	Hi-SVF	2/3" 380K		$1600 list price

Table 1. Electronic still camera systems that have been demonstrated or placed on the market.

2. SYSTEM ANALYSIS

The end user, the customer, of an ESC will measure the quality of the system by how well the images it produces compare to the images that he or she can currently obtain from a conventional 35 mm film–based system. In this section the foundation will be laid for how to analyze the ESC system, and the results will be used in subsequent sections to demonstrate the importance of the separate technologies to the final image.

Figure 4 shows an image quality polygon. It is an attempt to graphically show the magnitude of the quality of each of the major components of the ESC system. The radial, outward spokes indicate the level of quality of each of the components normalized by some convenient scaling factor.

A short definition of each term will now be given.

1. Resolution: for an ESC this is usually defined by the number of pixels per image sensor, but film systems usually use the modulation transfer function, MTF, to define image resolution and sharpness, which is more accurate.

2. Sensitivity: this is equivalent to film speed and can be expressed as an equivalent ISO speed or the minimum illumination (typically measured in lux) required to capture a high quality image.

3. Exposure Latitude: this is the range in exposure over which the ESC can record subjectively determined high quality images; the exposure latitude can be expressed in terms of a ratio, for example, 400:1, in terms of stops, about nine, or in absolute terms, 20 lux to 8000 lux.

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