Reviews on Digital Still Cameras

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1. Introduction

It is well known that the prototype of the electronic still camera "MAVICA" was announced from Sony Corporation in 1981. The news made a great sensation that new concept cameras require no chemical processing. Dozens' kinds of so-called video still cameras, where analog processing techniques are mainly adopted, have been designed and produced for these fifteen years.

But the video still cameras are used only in a few applications contrary to the expectations, because of limited potentialities of adopted methods and standards.

Instead of analog(video) still cameras, the digital still cameras are noticed in these several years rapidly.

It should be noticed that the essential concept of the digital still camera was already proposed by Wakui et al. (NHK) in 1981, at just the same year when the video still camera was announced, and the experimental model was made in 1982. [1]

But it takes more than 15 years that the digital still camera is put to practical use because of the technical and economical restrictions. The as cost of memory devices and fine processing techniques of semiconductor devices.

At the beginning of 1990's the sub-micron processing techniques are established and the memory devices becomes nearly one tenth in cost and four times larger in capacity.

The digital still cameras are rapidly noticed instead of analog(video) still cameras as one of multimedia input tools in these several years, coupled with PC(personal computer) popularization.

Here the outlines of digital still cameras are reviewed and the features required for imaging devices are discussed.

2. Classification of Still Cameras

Electronic still cameras are classified into four categories by its technology and use.

2.1 Analog Still Video Cameras

It was the electronic cameras of first generation. It was classified by its recording media and method. Frequency modulated video signal is recorded on a small magnetic floppy disk. The disk is known as Video Floppy, with a diameter of about 5cm (2-inch) and covered itself with a hard plastic case. Luminance signals and line alternated differential chrominance signals are separately frequency modulated on multiplex carriers, and recorded on a track. The disk has 50 tracks, and rotated synchronously field rate of video signal. [2]

Various imagers were adopted, MOS, Frametransfer-CCD, Interlinetransfer-CCD. Because electronic shutter technology of imagers had not be practicable, they equipped Mechanical shutter and controlled accumulation time of images.

The Cameras obtained enough image quality for appreciating images on a TV set, but it was not much attractive compared with the Camcoders.

Cameras of this category originated in MAVICA, and had been produced from 1985 through 1992, and almost 100 thousands were produced.

2.2 Digital Still Cameras

"Digital Still cameras" are the general term for equipment for capturing digital still images on a field or studio. Document or film scanner is not inclusive.

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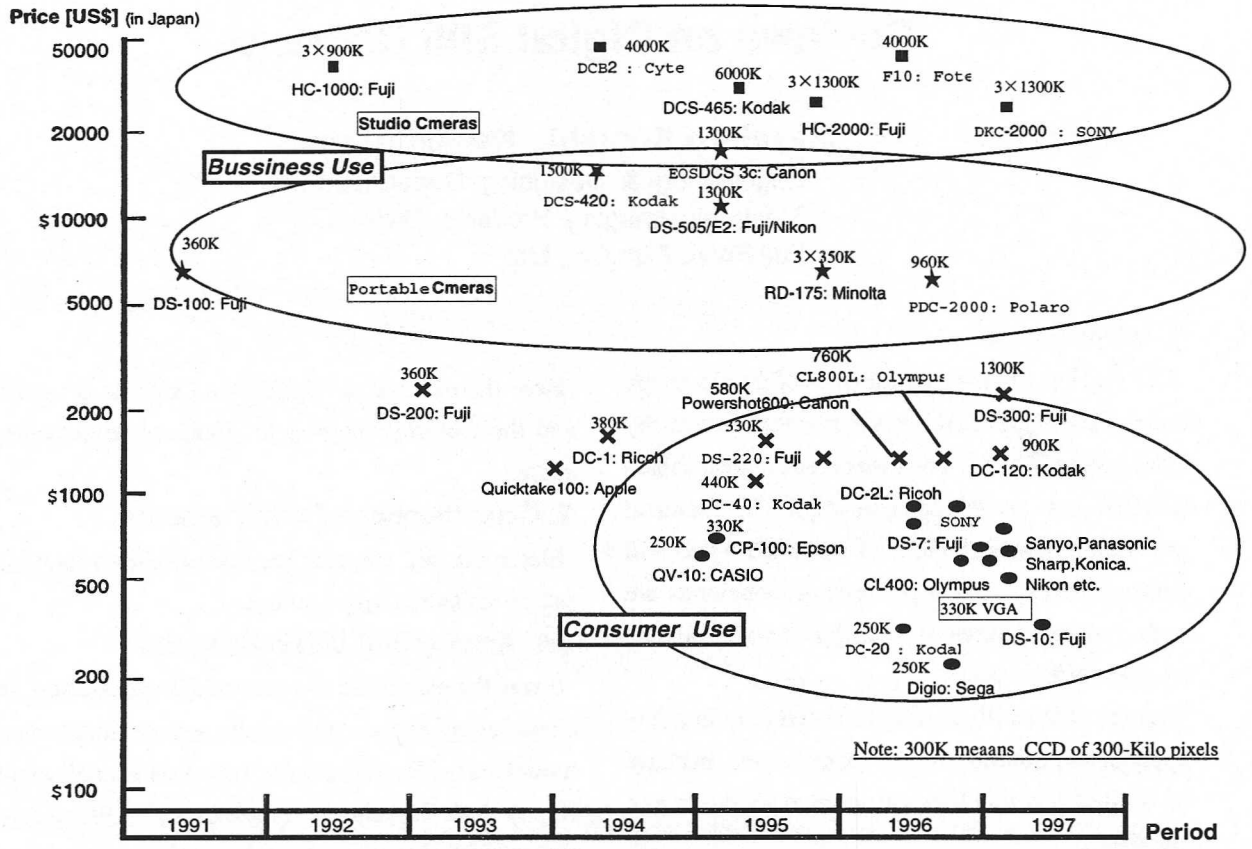

FIG.1 ANNALS of DIGITAL STILL CAMERAS

These second generation cameras are making rapid progress now. Progress is maintained by that of surroundings, that of the personal computers, digital data transmission technology, and other digital imaging equipment. (FIG.1)

In 1992 DS-100 (Fujifilm) was the first digital still camera product onto a market. At that time, the analog still video cameras were priced below $1000. On the other hands price of the digital still camera was 5 times as much as that of analog ones. The market of digital camera was mainly started in business applications, then as its price reducing, consumer market was opening out.

2.2.1 Digital Still Cameras for business use

-1. Studio Cameras: For Prepress, Industrial, Medical imaging use

This type of cameras are not portable, can be set in the photo-studio, attached on microscopes or on other measurements, to acquire highest image quality.

The pixel amounts of cameras are up to 1-16 millions, and high speed Image data bus to host computer, such as SCSI, is equipped. Camera is mainly controlled by the host computer. Some of these cameras can be attached back of the conventional studio photo camera.

The cameras are grouped into next 3 types by scanning methods

(1) 1 shot type

3 imagers are mounted after color-separation prism, similar to that of TV cameras for broadcasting use. Image can be exposed instantly with flashlight, and color images are acquired in one shot. HC-2000(Fujifilm) is this category.

Using huge single-chip color CCD is another solution for one shot. DCS-465(Kodak) is one of representatives.

(2) 3 shot type

Tarlet of color separation filters are used and exposure is made for each RGB color. F10(FOTEX) and DCB2 (Leaf) are representatives.

(3)Line Scanned Type

Line imagers are used, scanning is achieved mechanically. A process is quite same as that of flatbed-scanner. It requires few minute's exposure times, but it attains high resolution image.

-2. Portable Camera: For Newspaper, Insurance, Maintenance

SLR-type Digital still camera. The body of the camera is conventional SLR-camera, but CCD is mounted at the back instead of photo-film. These type cameras equip removable recording media to record captured images, such as PCMCIA flashmemory-card (PC-Card) or hard disk drive .Imagers are 1-6 millions pixels single chip color CCD, 3-CCD. DS505(Fujifilm/Nikon), DCS-1(Kodak/Canon) are representatives.

2.2.1 Digital Still Cameras for consumer use

The cost of CPU-chips, memory devices, digital signal processing LSIs, CCDs are getting less and less, consumer market of digital still camera are growing.

QV-10 (CASIO,1995) was first product for hobby users. 250K FT-CCD, 2MB flash-memory, 1.8-inch LCD-display, are mounted in a light and small body. It is easiest article to capture images for PCs. The image size (320*240) and quality are just fit for Web homepage.

Most recent trends of imagers are VGA (480*640)-size Progressive-scan- CCDs with true square pixel, and RGB color filter. Imagecompression technology is applied before writing the imagedata to flashmemory or memory card. Most of cameras up to the JPEG image compression standard. Removable memory card slots are equipped to some cameras, such as SSFDC(Smartmedia), Compactflash, Miniature-card, smaller than PC-card.

LCD monitor is installed in the body, as a view finder and playback monitor, is distinctive

DS-7(Fujifilm) is a camera, features described above are fully equipped. CL-400L(Olympus) is one of representatives without the memorycard, directly connected to PC by serial transmission line.

The cost trend is $350 to $700.

Now they have a tendency to increase amount of pixels to acquire higher definition images. 800K to 900K pixel Interlinetrnsfer-CCD are started to use for consumer cameras, such as CL-800L(Olympus) and DC120 (Kodak). In a year, over 1M pixel CCD will be mounted on some consumer cameras

3. Technology of Digital Still Cameras.

In this section we make explanation on block diagrams of two types ofcameras.

3.1 A Camera with Hardware Image Processing --DS-300 (Fujifilm) (FIG.2)

DS-300 is a middle range camera with 1.3M pixel VT-CCD with electronic shutter.

They consist of 3 signal processing LSIs and 2 dataflow controller LSIs.

The RGB image data read out from CCD is directly stored in the DRAMs. Then concealment for defect pixelsof CCD is provided by software.

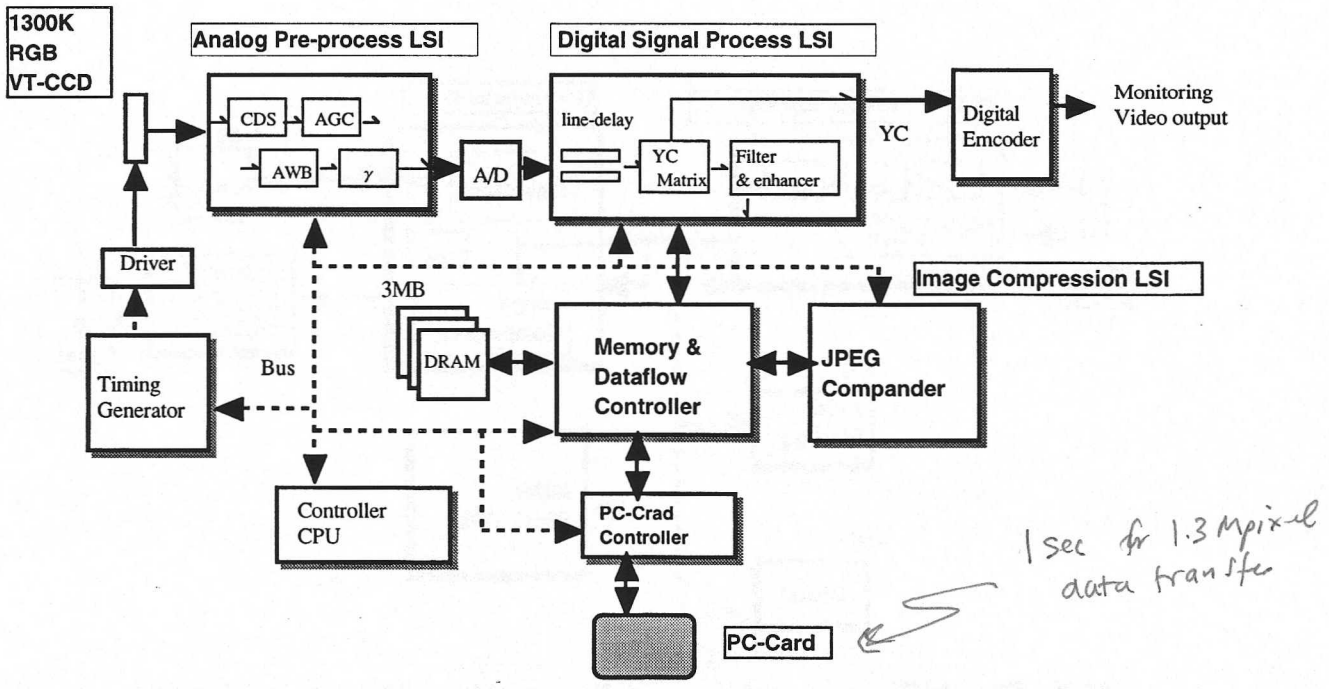

FIG.2 Block Diagram of Image Processing Circuitry (DS-300)

Next step the image RGB signals read out from DRAM was processed by DSP and converted into Y,Cr,Cb component signals, and stored in the DRAMs again. The third step, signal from DRAMs was processed by JPEG compression LSI, and continuously transferred to the PC-card through the Card controller LSI. Its whole signal processing speed is only a second for 1.3M pixels, that is one of the fastest. [3]

The merit of hardware processing technique is its processing speed.

3.1.2 A Camera with Software Image Processing —QV-10 (Casio) (FIG.3)

QV-10 is one of example of software processing of image data. RISC-CPU plays two rolls both image data processing read out from CCD, and image controlling data flow through its data-bus, from CCD to VRAM, VRAM to flashmemory, flash -memory to serial transmission line. [4]

The merit of software processing technique is flexibility of processing sequence, and its cost. The demerit is the speed. It takes 5sec. for 250k pixels. But It will be overcome in the near future, by drastic improvement of CPU clock rate. The data processing and Image compression are handled by RISC-CPU in some other recent cameras .

4 CCD for the Digital Still Cameras

Recent advance in CCD image sensor is driven by consumer video cameras. Requirement of its characteristics is certainly different from that of still cameras. We give some explanations for several required characteristics of CCD especially for the still cameras.

4.2.1 Shutter

Shutter operation is required to capture still images of moving object. Those three methods are actually used in still camera.

(1) Frametransfer-CCD with mechanical shutter

(2) Inaterlace scan interline-transfer-CCD with mechanical shutter

(3) Progressive -scan interline-transfer-CCD with electronic shutter

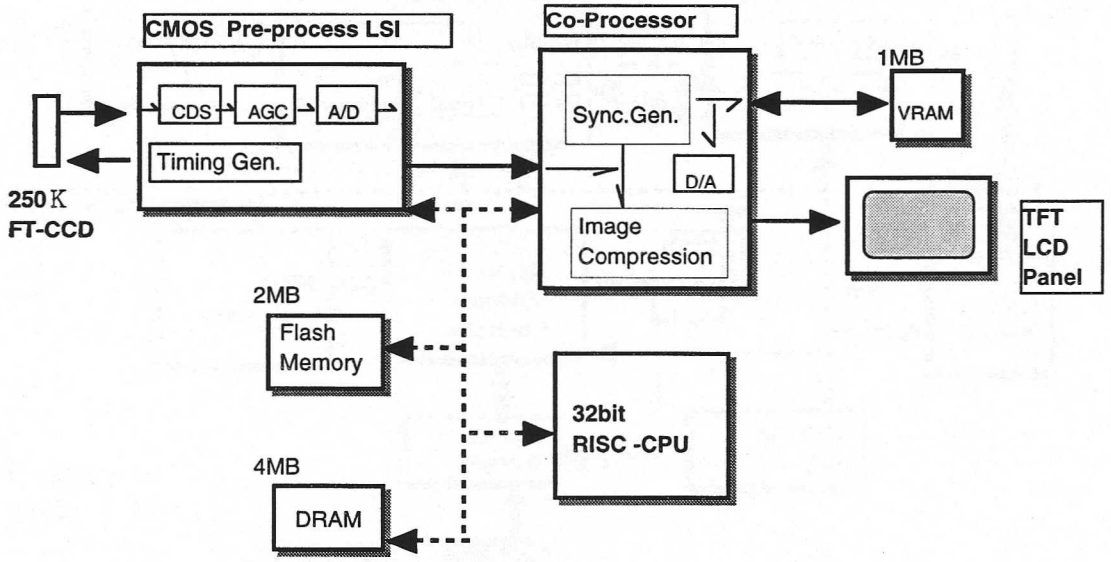

FIG.3 Block Diagram of Image Processing Circuitry (QV-10)

4.2.2 Full frame scanning

To acquire electronic shutter operation without reducing vertical resolution, progressive scan interline-transfer CCD is required. Progressive scan is accomplished by making packet between photo-diodes by three layer's poly-silicon vertical electrodes.

Another way is VT-CCD, which is arranging shift register beside of interlinetransfer -CCD to wiping out the charge to horizontal register line by line.(FIG.4,FIG5) [5]

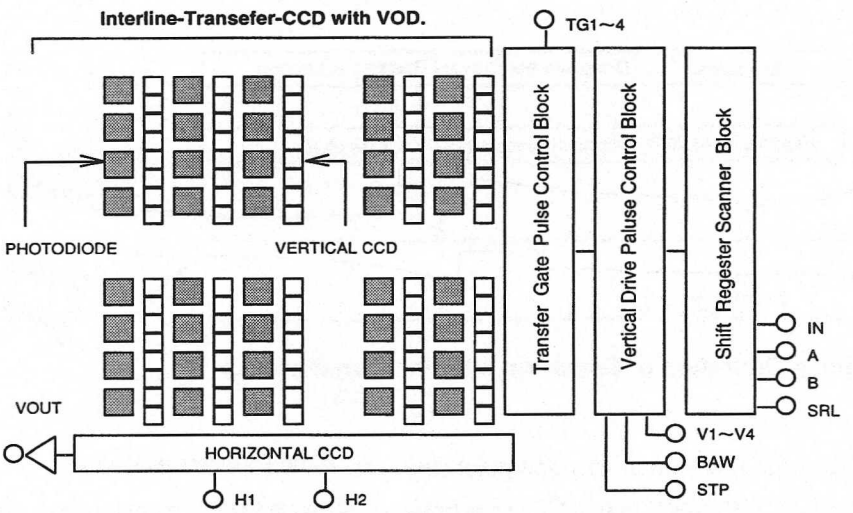

FIG.4 Scematic Diagram of VT-CCD

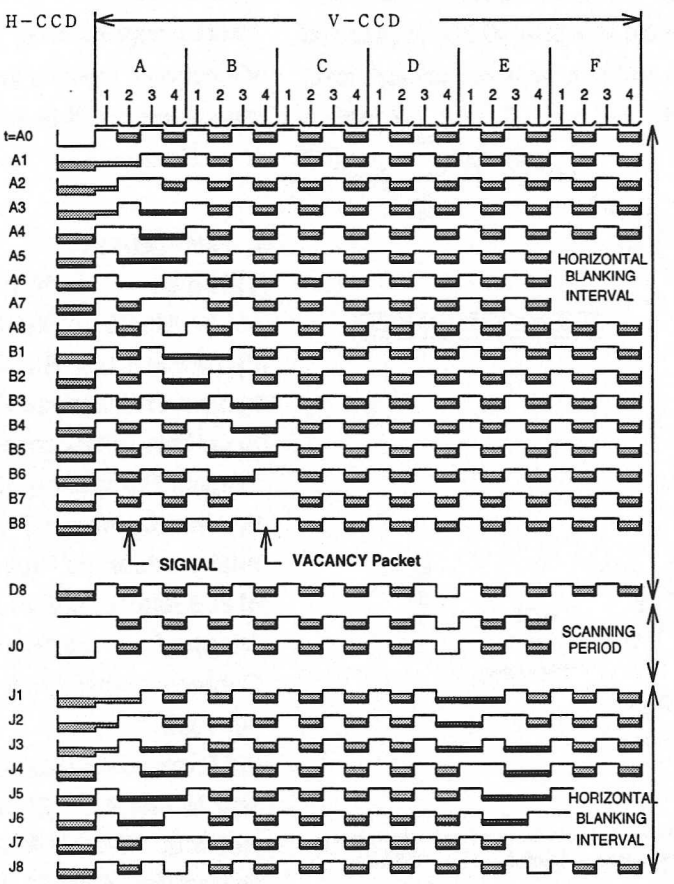

FIG.5 Potential diagram of VT-method

4.2.3 Smear

Smear makes particularly severe damage on the still image. Main image accumulated in photodiode and smear leaking to the vertical register may be seen double image, in high speed shutter exposure conditions or in flash light synchronization. To avoid smear,best way is to close mechanical shutter and to drain charge in the vertical registers before transferring charge from photo diodes.(FIG.6)

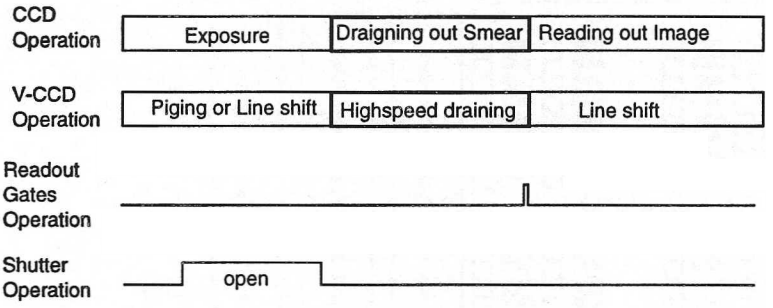

FIG.4 Draining Operation of Smear on Interline-transfer-CCD

4.2.4 Noise

The photon shot noise is dominant in small pixel size high resolution CCD. 1/3" 1090k pixels CCD has been already developed. Its pixel pitch is 4.7um square. Estimated saturation electrons are less than 10000. Signal to noise ratio may be less than 30 dB, in practical gray level exposure condition. It is not enough level for hard copy use (FIG.7)

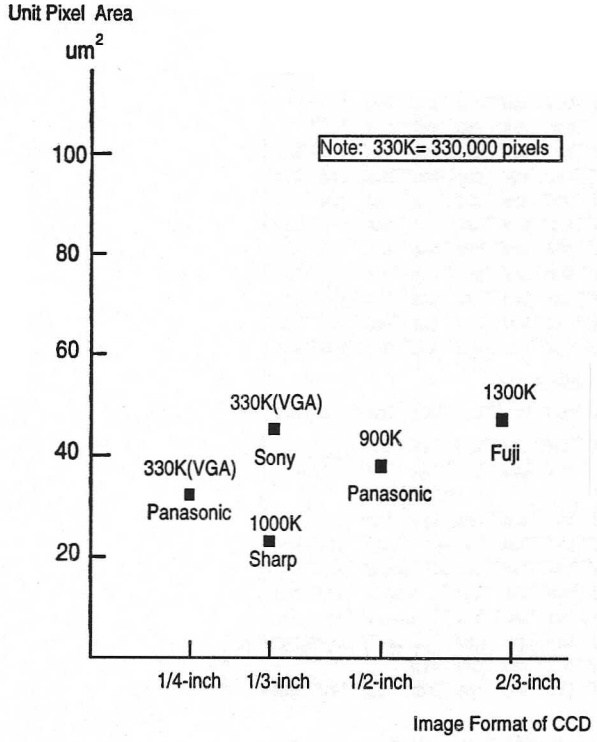

FIG.7 Unit Pixel Area of CCDs for Still Camera

5. Conclusion

Digital still camera is now taking the first step for the practical use. It is difficult to tell what the digital still camera should be. We wish we could give some useful information to CCD engineers about the digital still camera. We believe that, popularization of the digital still camera and improvement of its characteristic is mainly attributed by improvements of high resolution CCD.

6. Acknowledgments

We wish to express our appreciation for giving us such an honorable chance to present our reviews on the IEEE CCD workshop.

We also appreciate Mr.Shozo Iijima, General manager of electronic imaging department., Fujifilm for his encouragement, and members of our division for useful discussions.

7. References

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