INTERNATIONAL JOURNAL OF ENGINEERING TECHNOLOGY AND SCIENCES (IJETS) Vol. 2 (1) DEC 2014
DOI: http://dx.doi.org/10.15282/ijets.2.2014.1.3.1010

Various Techniques Involved in Acquisition of Image Using Image Sensors

J Rama Tulasi
Assistant Professor
Malla Reddy Institute of Engineering and Technology
Maisammaguda ,Secunderabad

Sai Preetham Sata
B-Tech (Mechatronics)
SRM University,Chennai,Tamil Nadu
saipreethamsata@gmail.com

Sata Venkata Yesoda Bhavana
B-Tech
Electronics and Instrumentation
SASTRA University, Tamil Nadu

Abstract*— Image sensors are being used predominantly in almost every aspect of science and technology. When an image is captured by a network camera, light passes through the lens and falls on the image sensor. This image is converted to voltage and it is further converted to digital format that act as input signal for the PC host.** *The image acquisition is done using single sensor,* **in-line arrangement of sensors in the form of a sensor strips or in the form of a 2-D array of individual sensors. The following paper deals with the various techniques involved in the design of the image sensors and few methods are being discussed to overcome the demerits in the above sensors.

I. INTRODUCTION

Image sensors are overwhelmingly used in the field of astronomy and defense applications and automation industries. These are basically used to acquire the image in the form of analog voltage. The amount of voltage that is produced is dependent on the light intensity acquired by the sensor. The light intensity acquired by the sensor is generated by the combination of an "illumination" source and the reflection or absorption of energy from that source by the elements of the "scene" being imaged. For example, the illumination may originate from a source of electromagnetic energy such as radar, infrared, or X-ray energy. The light energy is transformed into a voltage by the combination of input electrical power and sensor material that is responsive to the particular type of energy being detected. The output voltage waveform is the response of the sensors, and a digital quantity is obtained from each sensor by digitizing its response. The image acquisition is done using single sensor, in-line arrangement of sensors in the form of a sensor strips or in the form of a 2-D array of individual sensors. Single point laser scanner, computer radiography, photodiode are some of the examples of image sensors using single sensor. Flatbed scanner, film scanner .These type of sensors also acts as basis for medical and industrial computerized axial tomography (CAT) imaging. Charge coupled device (CCD) sensors; CMOS (Complementary Metal-oxide Semiconductor) image sensors are examples of the sensors that use an array of individual sensors to acquire the image. Microwave image is one of the imaging techniques that are used to detect the hidden objects using electromagnetic radiation in the frequency range of microwaves. RADARS and LIDAR are some of the examples of microwave imaging. Thermal imaging also utilizes electromagnetic radiation but the frequency range varies in infra-red(IR) region .Digital still cameras, machine vision, security and surveillance, video conferencing and camcorders, mobile phones, document scanning, medical imaging, PC cameras, barcode readers, scientific imaging, aerospace and defense , automotive, toys and games, biometrics are some of the applications where image sensors are being used profoundly. Due to the growth in demand for cameras, camcorders, multimedia mobile phones, and security cameras, the image sensors' market is experiencing significant growth. Due to advances in technology, high definition image sensors with increased resolution are being developed.

II. IMAGE ACQUISITION USING A SINGLE SENSOR

The most common sensor of this type is the photodiode, which is constructed of silicon materials and whose output voltage waveform is proportional to light. The usage of a filter in front of a sensor improves selectivity. For example, a green (pass) filter in front of a light sensor favors light in the green band of the color spectrum. As a consequence, the sensor output will be stronger for green light than for other components in the visible spectrum.

In order to generate a 2-D image using a single sensor, relative displacements should be present in both the x- and y-directions, between the sensor and the area to be imaged. This arrangement is similar to the one used in high precision scanning, where a negative film is mounted onto a drum whose mechanical rotation provides displacement in one dimension. The single sensor is mounted on a lead screw that provides motion in the perpendicular direction. Since mechanical motion can be controlled with high precision, this method is an inexpensive way to obtain high-resolution images. Other similar mechanical arrangements use a flat bed, with the sensor moving in two linear directions. These types of mechanical digitizers are also referred to as microdensitometers. Another example of imaging with a single sensor includes placing a laser source coincident with the sensor. Moving mirrors are used to control the outgoing beam in a scanning pattern and to direct the reflected laser signal onto the sensor.

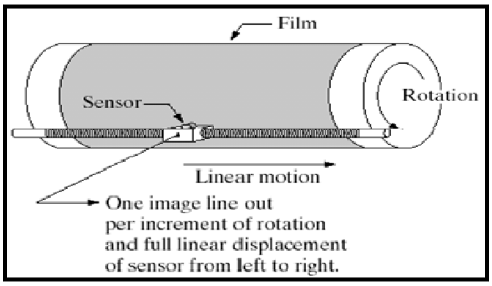

Fig 1 Single Point Laser Scanner

Digital images are often corrupted with noise and various other artifacts which significantly degrade the image quality and make the techniques involved in the processing of image complex. Some of the defects that arise in the single sensor imaging are image noise, coloration, demosaicking artifacts, exposure shifts and compression artefacts.

III. IMAGE ACQUISITION USING SENSOR STRIPS

It consists of an arrangement of sensors in one line to form a sensor strip. The strip provides imaging elements in one direction. Motion perpendicular to the strip provides imaging in the other direction .This type of arrangement is used in most flat bed scanners. Air borne imaging applications are the most common applications where we find these sensors to be of a significant role. In these applications, imaging system is mounted on an aircraft that flies at a constant altitude and sped over the geographical area to be imaged .The imaging strip that responds to the electromagnetic spectrum is mounted in the direction perpendicular to direction of motion of flight. The imaging strip gives one line of an image at a time, and the perpendicular motion of the strip completes the other dimension.

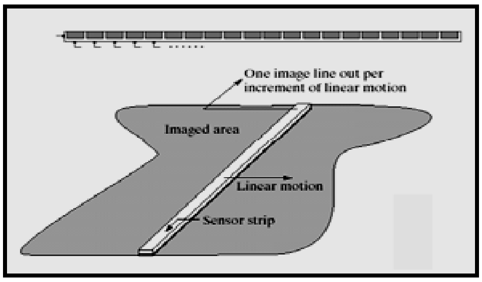

Fig 2 : Image capture by sensor strip

Computer converts the data into square array and thus the image is acquired.

IV. IMAGE ACQUISITION USING AN ARRAY OF SENSORS

Sensors are arranged in the form of arrays called pixels and light energy is focused on the pixels and converted into analog voltage .This analog voltage is converted into digital format by an ADC Converter and fed to the PC Host. Some of the sensors which use this technique are Charge coupled device (CCD) sensors and CMOS (Complementary Metal Oxide semiconductor) image sensors. In CCD image sensor, the light (charge) that falls on the pixels of the sensor is transferred from the chip through one output node, or only a few output nodes. The charges are converted to voltage levels, buffered, and sent out as an analog signal. This signal is then amplified and converted to numbers using an A/D-converter. Better light sensitivity, low sensor complexity, moderate to fast speed, high fill factor, electron pixel signal and less noise are some of the characteristics of CCD. Higher power consumption and complex analog circuitry pose barriers to the usage of CCD image sensors.

The complementary metal-oxide semiconductor (CMOS) sensor consists of millions of pixel sensors, each of which includes a photodetector. As light enters the camera through the lens, it strikes the CMOS sensor, which causes each photodetector to accumulate an electric charge based on the amount of light that strikes it. The digital camera then converts the charge to pixels that make up the photo. CMOS chips have several advantages. Unlike the CCD sensor, the CMOS chip incorporates amplifiers and A/D-converters, which lowers the cost for cameras since it contains all the logics needed to produce an image. It is possible to read individual pixels from a CMOS sensor, which allows 'windowing', a phenomenon where parts of the sensor area can be read out, instead of the entire sensor area at once. In this way, a higher frame rate can be delivered from a limited part of the sensor, and digital PTZ (pan/tilt/zoom) functions can be used. CMOS sensors are used significantly for the low end applications such as mobile phones. Low sensitivity, low fill factor are some of the demerits possessed by the CMOS sensors. CCD image sensors are more expensive to produce because they are manufactured using a more specialized manufacturing process. According to statistics, it takes approximately 18 months to develop a new CMOS chip, whereas it takes about eight months to develop a simple CCD chip.

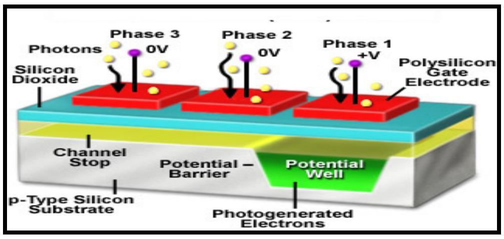

Fig 3: CCD Sense Element (Pixel) Structure

Effect Of Electronic Shutter Voltage On Charge Transfer In Ccd Image Sensor

An image is captured by converting the light from an object into an electronic signal at the photosensitive area (photodiode) of a solid−state CCD or CMOS image sensor. The amount of signal generated by the image sensor depends on the amount of light that falls on the image, in terms of both intensity and duration. Therefore, like conventional film cameras, digital cameras require some form of shutter to control exposure. This is generally achieved either by incorporating an external mechanical shutter in front of the image sensor or by an on−chip electronic shutter. When an electronic shutter operation is performed the voltage is shifted to second level. An image sensor such as interline charge coupled sensor can be damaged when the pixel is exposed to bright light during the shutter operation. The damage is caused by the bipolar junction transistor formed within the sensor. An n-type vertical CCD channel becomes the emitter of the transistor formed, the grounded p-well forms the base and the n-type substrate forms the

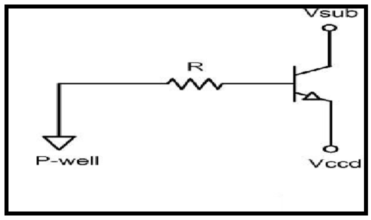

Fig: 4 Terminals of Transistor within a sensor

collector. At the centre of the pixel, p-well resistance is very large .The generation of photocurrent on exposure with light is faster than the time required to drain it away. When a bright light falls on the pixel, it shorts the electron shutter voltage and turns on the transistor. This high voltage on vertical CCD induces charge on vertical dielectric which causes increase in dark current in the vertical CCD. With the continued exposure of the bright light it also induces charge in the gate dielectric that results in poor charge transfer and image lag.

Recent Technologies Developed To Improve The Photosensitivity And Reduce Shutter Voltage For A Ccd Sensor

Charge-Coupled Device (CCD) image sensors with a smaller chip and higher photo-sensitivity are in high demand in the consumer market for compact digital still cameras. Reducing the pixel size causes the drop in photosensitivity and increase in shutter voltage. To increase photo-sensitivity, scientists have developed an incident light anti-reflective film technology and a shallow surface p -layer technology. To reduce VOD shutter voltage, development of an epitaxial grown substrate with double impurity concentration layers with optimal impurity concentrations and thicknesses has taken place.

On the conventional structure, the SiO_2 insulator film is formed on the surface of the photodiode. This type of structure reflects 20–30% of the incident light at the silicon surface because of the refractive index difference between the SiO_2 and Si. In the new structure, a Si_3N_4 film sandwiched by SiO_2 is formed on the surface of the PD to act as an anti-reflective film .The reflectivity property depends on the variability in thickness of SiO_2 and Si_3N_4.The results show that, with thickness of SiO_2 as a parameter, the suppressing ability of incident light reflection is more, compared to the results obtained by taking Si_3N_4 thickness as a parameter.

The results show that smear-noise was strongly affected by the impurity concentration profile at the silicon surface, apparently due to the charge diffusion from the PD to V-CCD, through the lower impurity concentration layer at the silicon surface. The optimal impurity profile design of the p -layer is clearly effective in reducing smear-noise. To reduce shutter voltage, it is necessary to suppress the growth of the depletion layer because suppressing the growth of the depletion layer results in the substrate voltage controlling the potential barrier in the p-well effectively.

It is observed that by using an epitaxially grown substrate with double impurity concentration layers and optimizing the impurity concentration and thickness of the epitaxial layers, the VOD shutter voltage could be decreased linearly by logarithmically decreasing the thickness of the top epitaxial layer.

Recovery of Poor Responsitivity From Uv Radiation In A Ccd Sensor

CCD often shows poor response towards incident UV radiation. The low responsivity is because of the small penetration depth of UV in silicon. Two different approaches to improve this limitation are: structural modifications to the CCD and post-processing of deposited phosphor coatings. Structural designs such as back-side thinned devices and pinned photodiodes exhibit good characteristics but require complicated fabrication processes that may be expensive to manufacture. Organic phosphor coatings to convert UV into visible radiation have been developed as a simpler, yet effective solution. Even though organic coatings exhibit good initial response, they photodegrade to zero efficiency exponentially. To cross this barrier caused by organic coating, inorganic coatings offer a suitable solution due to their unique characteristics.

The important parameters that should be considered to employ this coating are photostability, conversion efficiency, decay time, absorption and emission peak, particle size and distribution and film morphology. The selected phosphor should have conversion efficiency as close to 100% as possible. This is of particular importance because the luminescence mechanism is isotropic and 50% of the fluorescence is emitted away from the sensor. A fraction of this fluorescence will experience total internal reflection at the film–air interface and will be directed back toward the sensor. This fraction will improve the conversion efficiency.

CONFIGURATION OF IMAGE SENSORS

Image sensors can be configured in one of the following ways:

1) by mounting the sensor on the PC.

2) By creating a hybrid Package where the image sensor is integrated into the systems that also incorporate other sensors.

3) As an integrated circuit with microprocessor.

4) By putting the image sensor and smart electronics on a single chip.

The type of configuration can vary from application to application but the most common trend is to use a sensor IC with an integrated microprocessor. The most important functional features for an image sensor system are accuracy, reliability, image sharpness, performance under low-light conditions, easy download, transfer and replication of images, and long life.

V. CONCLUSION

Suitable image sensors are used for the acquisition of image based on complexity of application. For example, low end devices CMOS Image sensors are being used for the applications where high sensitivity is required.CCD Sensors are being used due to the technological advances that are being stimulated in recent years. Few parameters such as resolution, sensitivity, conversion efficiency etc are being improved. Latest cameras such as HDTV Cameras, Megapixel cameras are emerging in response of these technological advances.

VI. REFERENCES

[1] Ichiro Murakami, Takashi Nakano "Technologies to Improve Photo-Sensitivity and Reduce VOD Shutter

Voltage for CCD Image Sensors" *IEEE Trans on Electron Devices*, VOL. 47, NO. 8, August 2000

[2] Akihito Tanabe, Yoshiharu Kudoh , Yukiya Kawakami " Dynamic Range Improvement by Narrow-Channel Effect Suppression and Smear Reduction Technologies in Small Pixel IT-CCD Image Sensors" *IEEE Trans On Electron Devices*, VOL. 47, NO. 9, September 2000

[3] "single sensor imaging methods and applications for digital cameras" edited by Rastislav Lukac.

[4] "Image sensors in industrial applications" by Smithers apex

[5] "CMOS Image sensors " Abbas El Gamal and Helmy Eltoukhy .

[6] Wendy A. R. Franks, Martin J. Kiik," UV-Responsive CCD Image Sensors With Enhanced Inorganic Phosphor Coatings"

[7] IEEE T*rans on Electron Devices*, VOL. 50, NO. 2, February 2003.