Lesson 08:
Image Storage, Processing, Magnification, and Recording

These lessons contain 26 slides plus 8 multiple-choice questions.

These lessons were derived from pages 43 through 47 in the textbook:
Image Storage and Processing

Diagram:
- Beam Former
- Transducer
- Timing
- Receiver
- Image Storage
- Display
- Record
Image Storage and Processing

ANALOG OR DIGITAL?
Image Storage and Processing

ANALOG
Image Storage and Processing

DIGITAL
Image Storage and Processing

ANALOG

DIGITAL
The heart of the image storage component is the digital scan converter. A scan converter is used to convert the demodulated echo-amplitude information from the receiver along with echo-position information (based on timing), from its original format into a signal format that can be fed to a standard video display monitor or recording device. During the conversion process, the information is temporarily stored in the scan converter's digital memory. The digital memory is an electronic device that stores discrete signals. Employing multiple digital memories permits “cine-loop”, which is the real-time recording and playback of multiple image frames.
The echo amplitude and position information is normally *analog* which means that it does not represent discrete values. Before being fed to the scan converter’s digital memory, it must be converted to a digital format.
During the conversion to digital, discrete shades of gray are assigned to the incoming echo amplitudes. This process is called *pre processing*. Selectable pre processing (on some systems) permits the operator to vary the *texture* of the displayed image. Because pre processing occurs *prior* to the digital memory, changing the selection will not affect any image information once it is stored. Edge enhancement is a form of pre processing that sharpens the borders of a structure.
The accuracy of assignment of gray scale levels to B-mode amplitudes depends on the number of \textit{bits} (binary digits) of information that can be stored in the digital memory for each horizontal vertical location.

In a digital memory, based on a binary number system, the number of gray shades is equal to $2^n$, where \( n \) = the number of bits (binary digits) in the memory.
The greater the bit density, the better the contrast resolution.
A typical digital memory is configured with an image-matrix memory size of $512 \times 512$ which represents the number of rows and columns of digital picture elements, or pixels. The greater the matrix size (greater pixel density), the better the spatial resolution. Each pixel in a $512 \times 512$ matrix represents one of 262,144 discrete horizontal-vertical echo locations, each displayed as a specific shade of gray.
Information that passes through the digital memory must now be displayed. Because some video monitors and recording devices are designed to display analog information, the information that is stored in (or passes through) the scan converter's digital memory requires further image processing.
One image processing function that occurs after storage in the digital memory is the determination of the brightness level that will be displayed for each gray scale level. This function is called post processing or gray-scale mapping. Selectable post processing permits the operator to vary the emphasis that is given to various gray scale ranges. Since post processing occurs after the digital memory, it can affect stored and live images. Most ultrasound systems utilize some form of selectable post processing.
Magnification

WRITE
READ

ZOOM
MAG
RES
SCALE
SIZE
FOV
Another image function that may occur prior to the digital memory is *write magnification*. Selectable magnification prior to storage in the digital memory permits the operator to electronically change the size of the displayed image without a reduction in the number of displayed pixels.
All ultrasound systems utilize some form of write-magnification.
Image magnification in some ultrasound systems occurs after the digital memory. This magnification method permits an operator to enlarge a selected area of the display by *enlarging* each pixel. By enlarging each pixel, fewer pixels are present on the display. Images magnified in this manner have decreased spatial resolution and are coarse when compared to images that are magnified prior to storage in the digital memory.
Read magnification

By enlarging each pixel, fewer pixels are present on the display. Images magnified in this manner have decreased spatial resolution and are coarse when compared to images that are magnified prior to storage in the digital memory.

Some ultrasound systems that store raw echo data may permit magnification of the stored image without degradation caused by pixel enlargement.
**Recording devices**

*Laser imagers* produce multiple images on single sheets of film by capturing video frames to control the intensity of a laser beam that exposes the film using a sequential scanning technique. The exposed film or paper is developed in an x-ray film processor to provide **hard copy** images.

*hard copy*: a method of permanently preserving or recording image data on paper or film.
Black and white (monochrome) *thermal printers* use heat sensitive paper as a recording medium.
A color thermal printer produces a hard-copy color image by using a thermal head to melt portions of a multi-colored ribbon onto a special sheet of paper.
A color *ink-jet printer* operates by propelling drops of ink of various colors onto standard paper.
Analog and digital tape recorders and some disk recorders store image information using a magnetic medium. Magnetic recorders can be configured to record static or live images. Because playback equipment is required to view the recorded information, the recordings themselves are not considered to be hard copies. Magnetic storage media may be adversely affected by strong external magnetic fields.
Optical disk (e.g., CD, DVD) recorders can also record static and live images. Like magnetic recording devices, playback equipment is required to view the recorded information. Optical storage media is not affected by external magnetic fields.
Recording devices

DICOM compatible images can be stored digitally in a PACS (Picture Archiving and Communication System). Image data is typically stored in RAID, which can be configured for higher capacities than CD, DVD, or tape. Images are displayed on high resolution monitors for subsequent diagnosis. Hard-copy prints may be produced by the PACS when required.
Answers to the following **EIGHT** practice questions were derived from material in the textbook:
An ultrasound system has a digital memory. If the output signal from the receiver is analog, what is needed for proper storage of echo amplitudes?

- a modem
- high pulse repetition rates
- pre processing
- a hybrid matrix
- post processing
The TV display monitor in an ultrasound system receives its signal from the

- matching layer
- pulser
- pre processor
- receiver
- scan converter
A digital picture element is a

- voxel
- bit
- microprocessor
- pixel
- matrix
An ultrasound system that stores and displays 256 discrete gray shades has

- a digital memory with 256 bits
- a digital memory with 8 bits
- a digital memory with 4 bits
- an analog memory
- a digital memory with 16 bits
What can be used to alter the displayed brightness of an image that has been stored in the memory?

- pre processing
- write magnification
- log compression
- dynamic range
- post processing
The type of image magnification that results in the enlargement of individual displayed pixels is

- write zoom
- magnification after the digital memory
- RES magnification
- SCALE magnification
- DEPTH magnification
The image on the ultrasound system's display monitor is normal, but the gray scale quality of the hard-copy image is poor. What should be adjusted to correct the problem?

- post processing
- pre processing
- TV monitor
- the hard-copy imager
- TGC
What is the type of medium that is used for video tape recording?

- magnetic
- thermal
- optical
- paper
- non-ferrous
END OF LESSONS 08