The development of the imaging camera.... CRT to Laser

The multiformat camera

Whilst very few multiformat cameras, based on cathode ray tube (CRT) technology, are purchased these days, it is important to review that technology in order to assess both the impact and potential of laser imagers.

Early imaging cameras bolted directly onto the diagnostic monitor (Figure 1) had special lenses to

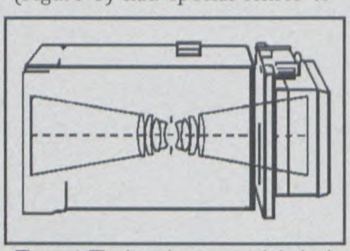

Figure 1: The imaging camera is bolted directly on to the diagnostic monitor.

compensate for spherical aberration because of the curved screen. The applications of these cameras were in the fields of ultrasound and first generation CT scanners.

Next came the dedicated multiformat camera, so called because multiple exposures could be made on the same film. These cameras are video based, that is they require a video signal in order to work. Such a camera featured a flat screen CRT tube, in-line optics and electronic control. The various challenges faced with this type of camera are as follows:

Stability

The image on the CRT is built up from the electronic beam crossing the tube at least 625 times from top to bottom. Each sweep constitutes a line (a raster line) with a set of 625 lines constituting a frame. A frame is built up 25 times a second. With conventional film an exposure of about 10 frames will be necessary to form an image. It follows, therefore, that each line on each frame must be in exactly the same position on the screen in order to produce maximum sharpness in the image. Any instability will result in the raster lines being blurred with a resultant loss in image quality.

Exposure

As stated above, 25 frames a second are produced on the monitor screen. The minimum exposure time is thus 1/25th of a second. On later multiformat cameras a method of determining exposure by number of frames (or fields) was developed.

An additional issue in determining exposure is the monitor brightness. A change in exposure time causes a sensitometric change in the film's characteristic curve similar to the effect caused by increasing monitor brightness. Additionally, an increase in monitor brightness can cause a deterioration in image sharpness due to phosphor flare. It will be appreciated, therefore, that the monitor is set for a maximum sharpness / brightness compromise with exposure time determining blackness of the image.

Optical system

There are various problems associated with an optical system:

- Vignetting - a loss of brightness at the edges of the image. This is reduced by using a CRT screen that is larger than the image field
- Spherical aberration - this manifests itself as geometric distortion. This is overcome by the use of in-line optics and a flat screen monitor
- Density uniformity - a falling off of brightness at the edges of the screen due to variations in electron density on the phosphor. This is compensated for electronically by altering the brightness profile across the screen

The laser imager

1987 saw the advent of the laser imager with 3M introducing an infra red system to the American market. Today there are seven major manufacturers of laser imagers, namely Agfa, DuPont, Fuji, Kodak, Konica, 3M and Polaroid.

The output, that is the film, of the laser imager may look very much like that of a CRT multiformat camera, but that is where the similarity ends.

Input

Although provision can be made on most systems for a video input, laser imagers almost exclusively use a digital interface to the imaging modality. This has far reaching implications with regard to increased departmental productivity where different modalities can be connected to the same imager. Much research and development is underway developing Local Area Networks (LAN), Image Gateways, Picture Achiving and Communications Systems (PACS) to fully utilise the potential of laser imagers.

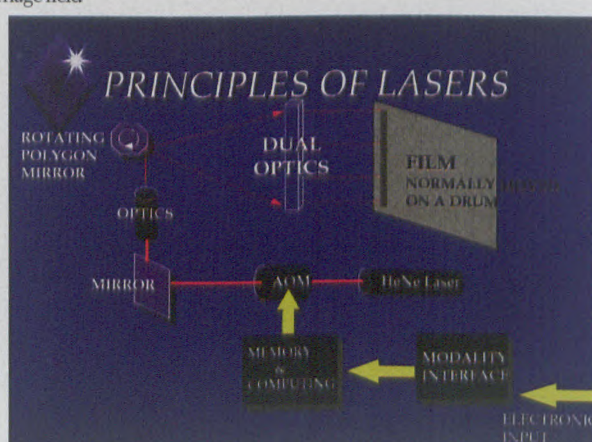

Figure 2: Principles of laser

Basic principles

The following is a description of the operation of a Helium Neon (HeNe) laser: (Figure 2)

The data from the imaging modality is inputted via the interface electronics and an image buffer which acts as a storage device. The data are then split into x-axis; y-axis and intensity information.

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The intensity of the laser beam is varied by means of an Acoustic Optical Modulator. This is a very stable system which delivers 4096 grey levels (compared to 200 on the CRT). The beam is then swept to and fro across the film by a system of lenses and a rotating or galvanometric mirror (x-axis). At the same time the film is transported in the longitudinal direction by a precise mechanical drive system (y-axis). The image is thus "painted" on the film from top to bottom in sequential lines by a very fine laser beam which achieves a pixel size of 80μm. By this means problems of geometric and density distortion common to CRT imagers are avoided.

Exposure

The one main disadvantage of the laser imager against the CRT imager is exposure time. On the CRT it is approximately 40 ms. The laser imager takes anything from 17 to 45 seconds per film. Because of its digital architecture, however, the data for an image can be stored in a queue to maximise throughput. In addition multiple copies can be made independently of the imaging system (CT Scanner, MRI, etc.).

Resolution

The resolution of a laser imager is in the region of 6300 X 7650 pixels. This applies to the whole film. With a CRT camera the resolution of 1250 lines applies to each image. With 12 exposures on a 35 X 43 cm film the resolution of each system is comparable. With less than 12 exposures on a film, the laser imager is superior.

This is the first in the series "Technology Refresher Course". We would welcome feedback as to whether the subject material is correct, whether the information should be more in-depth, and suggestions about what subjects should be covered in future issues.

The author wishes to thank Agfa, DuPont and Konica for the information they provided towards this article.

Roger Short
Publisher

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