EMERGENT: JOURNAL OF EDUCATIONAL DISCOVERIES AND LIFELONG LEARNING (EJEDL)
ISSN: 2776-0995 Volume 4, Issue 12, December, 2023

ANALOG AND DIGITAL IMAGE IN MEDICAL RADIO DIAGNOSTICS

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Abstract:
The differences and advantages of analog and digital images in medical radiation diagnostics are considered. The most important directions in organ visualization are shown: obtaining functional images.

Keywords: analog, digital, images, medicine, beam, function, radiograph, radionuclide, pixel, bit.

Known that the entire variety of medical radiation images, regardless of how they are obtained, can be reduced to analog and digital images.

Analogue images include those that carry continuous information. These are images on ordinary radiographs, scintigrams, thermograms.

Digital images include those produced using a computer. They have a cellular structure (matrix), represented in the computer memory. Digital images are images obtained using computed tomography, digital radiography, fluoroscopy and angiography, MR imaging, computer scintigraphy with computer information processing, digital thermography, and ultrasound scanning [1].

Thus, digital images, unlike analogue ones, have the property of discreteness. Since digital images are based on computer technology, they become available for computer processing.

Analog images can be converted to digital, and vice versa, digital to analog. For these purposes, special devices are used: analog-to-digital and digital-to-analog converters.

A digital image is formed on a raster display in the same way as in television receivers, i.e. by scanning with an electron beam along the lines 30 times per 1 s. This creates a real-time image perception mode. To create a digital image, a special display processor is used, which is connected to the main computer through a communication system (interface).

The memory of the display processor is organized in the form of a matrix, each of the elements of which corresponds to its own specific area of the display screen. Such an elementary unit of a digital image, which corresponds to an addressable memory section, is called a "pixel".

Thus, the entire area of the raster display screen is a matrix - a collection of pixels. In radiation diagnostics, the display screen area can be formed in the form of matrices of 32x32, 64x64, 256x256, 512x512, 1024x1024 pixels. The more pixels the screen area of the display is divided into, the higher the resolution of the display system.

Each pixel of the image is formed in the memory of the display processor by a different number of bits (units of information) - from 2 to 16. The greater the number of bits of information represented by each pixel of the image, the richer the image in terms of viewing properties and the more information about the object under study it contains. Thus, a 16-bit pixel, most often used in ultrasound diagnostics, contains 26, i.e. 64 shades of gray (from black to white).

In radionuclide diagnostics, an 8-bit pixel (byte pixel formation system) is used predominantly; it has 28, i.e. 256 options for gray scale assessment levels. It is easy to calculate that a 64x64 pixel matrix image in radionuclide diagnostics requires 4069 bytes of memory, and a 128x128 pixel image requires 16,384 bytes.

More advanced radionuclide diagnostic systems have images of 256x256 and even 512x512 pixels. To form such images, with an 8-bit pixel, approximately 64 and 256 kilobytes of computer memory are needed, respectively. An increase in the amount of addressable memory inevitably leads to a decrease in the speed of information exchange, which is accompanied by an increase in the time required to construct each image frame.

In this regard, small rasters (256x256 and 512x512) are used primarily for obtaining static images with high spatial resolution, i.e., in the diagnosis of focal changes in organs, while large rasters (64x64 and 128x128) are used mainly for dynamic studies.

CT scans use 2-byte pixels (16-bit). With a matrix size of 512x512, obtaining one CT scan requires about 412 kilobytes of computer memory. Approximately the same amount of memory is required to obtain one MRI scan [2-3].

In digital methods of fluoroscopy and radiography, a display with a very small matrix (1024x1024) is used. Such an image is practically indistinguishable from a conventional halftone analog image. However, obtaining this digital X-ray image requires more than 1 megabyte of computer memory. An even larger amount of memory (more than 2 megabytes) is required to construct one frame in digital subtraction angiography - a computerized contrast X-ray examination of blood vessels [4-7].

Color displays, most widely used in radionuclide diagnostics and thermography, require 3 times more computer memory than black-and-white ones, in terms of the number of primary colors - red, blue, green. It is clear that to implement such a task, powerful computers with well-organized software are needed. All medical images in radiology diagnostics can exist in two versions: in the form of hard copies - radiographs, prints on paper, photographic paper, on magnetic media - tapes, disks; in an unfixed form - on the display screen or x-ray diagnostic machine.

A significant advantage of digital images is the possibility of their computer processing. The first, preliminary stage of computer image processing is carried out during the collection of information, i.e. at the moment the image itself is received. For this purpose, image correction is performed to "correct" technical defects in radiation detectors, for example, inhomogeneity in sensitivity across the field of the scintillation sensor of a gamma camera. At the same stage, correction of physiological factors that worsen the image carried out. For example, during a radionuclide study of the kidneys, the influence of radioactivity present in the blood vessels and surrounding soft tissues excluded; when studying the liver, it is necessary to take into account and exclude the dynamic blurring of the organ caused by its displacements during breathing.

The next stage of computer image processing is analytical. It was carried out during image analysis. Thus, in order to improve the image, it is possible to carry out smoothing, i.e. leveling inhomogeneities, contrasting organs by cutting off the background that interferes with perception, and additional coloring of individual areas of the image.

To improve the identification of pathological foci in an organ, isocount curves created, i.e., lines connecting image points with the same accumulation of radioactive substance or having the same optical density, and profilograms also constructed showing the distribution of radioactive substance in the organ along an arbitrarily selected line. For the same purpose, a pseudo-volumetric, or axonometric, image of the organs obtained. Naturally, all these image transformations performed using a computer.

A unique form of image processing is frame algebra: adding or subtracting multiple images using a computer [5]. In this way, for example, the parathyroid glands are visualized by subtracting from one image obtained using the radionuclide thallium-201, another obtained using the radionuclide technetium-99.

A similar technique used to increase contrast and "link" images of tumors to anatomical landmarks. In these cases, two images added: one of them reflects the accumulation of a tumor-tropic substance in the tumor, the other - the shape and structure of the organ under study. The final summary picture gives a good idea of the location of the tumor in the organ.

Using a computer, you can process the curves obtained from the analysis of medical images. You can, for example, smooth out these curves, that is, make them more visual. Special computer processing programs make it possible to perform mathematical modeling of the functions studied, which helps to identify pathological changes and determine their severity.

Identification of areas of interest (areas of X-ray, radionuclide, ultrasound images) is one of the main stages of image processing on a computer. The area of interest can be the entire organ or part of it. One image may contain several areas of interest, for example, an area of the organ studied, surrounding tissues, or great vessels.

The doctor depending on the type of study and specific diagnostic tasks chooses the shape, size and number of areas of interest. This done using a cursor on the display screen or automatically, using a special image processing program. The selected area of interest studied separately or in conjunction with other areas. In a given area, you can use a computer to track the passage of a radiopaque substance or radionuclide over time. As result of this analysis, curves called histograms obtained. They reflect the function of the organ as a whole or its individual sections.

An interesting and promising area of computer use is the automated separation of medical images into normal and pathological ones. This treatment is especially effective during mass examinations, for example, during fluorography. In the future, with the help of computers, it will be possible to automatically assess pathological changes. One of the most important areas in organ imaging is obtaining functional images.

Three types of functional images can be distinguished: those characterizing the motor activity of the organ (contractile, evacuation, etc.):

- 1st type of image, characterizing the excretory function of the organ
- 2nd type, reflecting the metabolic activity in the organ
- 3rd type obtain functional images 1 type, i.e., the motor activity of organs can be examined on the screen of an X-ray diagnostic machine or the display of an ultrasound diagnostic device.

To register type 1 functional images, sequences of frames recorded on electronic media. A series of functional images can also be recorded and stored in the magnetic memory of computer.

To study the evacuation function of organs, special substances are first introduced into them - radiopaque substances for the X-ray method of study 18 or radiopharmaceuticals for the radionuclide method. By observing the emptying of an organ from the injected substance using radiation diagnostic devices, one can judge its evacuation function. The use of computer technology for these purposes makes it possible to evaluate the evacuation function of the organ in precise quantitative terms.

Type 2 functional imaging refers to the study of excretory function of organs. For this purpose, substances used that are selectively and quickly released from the blood by the organs being studied. In this way, for example, the excretory function of the kidneys or liver is studied.

Type 3 functional images are metabolic. They used primarily in radionuclide diagnostics. For this purpose, a radiopharmaceutical introduced into the body, which is involved in the metabolism in the organ under study.

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