MRI-systems designing and application specialists development

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Abstract

In the paper the requirements in the specialists, dealing with designing, testing, application and maintains of tomographic devices was analyzed. The adjustment of the new education techniques actuality is shown in field of tomographic devices development. Interactive and virtual programs, using in the MRI-systems designing and application specialists development are described.

Keywords: Medical equipment, MRI-systems, vendors, specialists development

1. Introduction

Tomography is one of the high-technology noninvasive diagnostic methods, used mostly in medicine. Examination quality directly depends on theoretical knowledge, qualification, technical outlook of the specialists in devices adjustment, testing and maintains. Specialists development must include not only theoretical knowledge in physics and information technologies, but experience of using laboratory complexes, deciding specific applied tasks, continuing advanced training [1-2].

At present, medical equipment (and particularly tomography) state is characterized by the absence of ability to get practical training at traditional forms of educational, industrial and scientific practices. One of the most real ways to provide students in 20010006 «Tomographic diagnostic methods» (master degree) and in 200101 «Instrument making» field with spatiality «Computed tomography» with practice in modern conditions are virtual laboratories development, study courses and scientific projects in common with medical organizations. In the paper the experience MRI-systems designing and application specialists development is discussed.

2. MRI-systems requirements analysis

MRI-systems are correspond to the high-technology equipment, whose main field of usage is medical noninvasive diagnostic. The medical topographic devices analyze (including computed, magnetic-resonance and positron-emission scanners) shows, that on the market the percentage of CT-scanners 53%, and for MRI-systems - 40%. In the first instance it can be explained by the high price of the MR-scanners according to CT. In 2006 in Saint-Petersburg 30 MRI-scanners were functioning (Fig. 1), simultaneously the percentage of domestic manufacturers was 13%. One of the MRI-systems developer and manufacturer was such major venture as Scientific Research Institute NIIFA named by D.V. Efremov, where superconducting magnetic-resonance scanners with a field strength 0.5T was developed. Annual MRI-systems increasing was about 5 machines when requirements was in 5-6 times greater.

Last 4 years we can see sharp increasing in the MRI-systems number. In the beginning of 2009 the total MR-scanners number was 43 units in Saint-Petersburg, including 14 systems from them were installed and gone into operation in 2008 and 6 were bought and being installed now. At once, the majority of MRI-units, developed before 1995, were de-installed, and this quantity includes domestic manufacturers scanners.
At present, the majority of installed systems were made by General Electric (37%) and Siemens (40%), and some devices produced by Philips, which wasn't presented earlier (Fig. 2). In 2008 the first 3T MRI-system was installed and operating now in International Clinic & Hospital "MEDEM".

Very often MRI systems service, developed by foreign vendors, is too expensive, so in this conditions engineers qualification comes out on top. Features of such devices construction and operating conditions mean specialists acquire knowledge of the newest products of the major vendors, measurement methods and algorithms, different ways for increasing measurement quality in clinic, troubleshooting algorithms and methods of their defects removal or decreasing faultiness influence. Training of the specialists in exploitation and service of tomographic complexes must include modern education technologies, which allow modeling of the different processes, and simulation of the measurements using different type and modalities devices. Particularly, in magnetic-resonance scanners specialists training very useful virtual tools, modeling device functioning, relaxation process and visualizing image quality (or such parameters as signal to noise ratio, contrast and spatial resolution) dependence on type of the pulse sequence, measurement method and examination parameters should be used. In computed tomography field it is very useful to simulate different scanning methods and algorithms and quality estimation for accuracy of investigating matter.
3. Magnetic systems designing and hardware analyzing

The modern innovation and information techniques are widely applied in different fields of science, including education. Information availability, developing and using of the special databases, different problems modeling allows to improve quality of the engineers education. At present there aren't any domestic training or informational systems and software for education in the computed or magnetic resonance tomography field. It caused by relatively recent appearance of such devices and also by low numbers of such machines until recently.

One of the education stages for specialists in any direction is studying of the developed equipment and analyzing of its characteristics. In MRI hardware (including magnet system type, gradient and radiofrequency subsystems, radiofrequency coils configuration) significantly influence on measurement accuracy. Moreover it is important to estimate operation characteristic of the equipment, for example, power requirements, cryogen liquid rate, cooling flow rate. The equipment selection and comparison must include its complex estimation.

Author design educational software, which database contains information about 107 MRI-scanner models, developed in 20 years, its main parameters, components, construction distinctive features and shows equipment differences, that makes specialists development more completed. Presented devices were design by such leaders in MRI as Siemens, General Electric, Philips, Toshiba, Hitachi, Esaote and other manufacturers. For each of the models there are its technical characteristics, application area, advantages and disadvantages, for visualizing database contains photos, demonstrating as construction features, as model series. All parameters were collected from the manufacturer official sites.

The structure of the interactive software allow to find systems with specified characteristic. As a search criteria's the manufacturer, year of the development, application area, construction type, magnetic system characteristics and field strength, scan modes, dimension of array or available visualization options can be chosen. Device abilities visual comparison performed by measured images, which help to estimate the degree of the some factors influence (including technical parameters of studying devices, application software function and reconstruction algorithms) on quality and accuracy of measured image and on diagnostic abilities.

The developed program is useful for practice training in the tomographic courses as for engineers studying, as for staff, whose job is medical equipment choosing and purchasing for hospitals and clinics.

4. Virtual and interactive modeling applications

The examination result estimation is one of the main problems in daily clinical practice. The examination planning is important part of the accurate diagnostic and depends on a number of factors. In MRI considerable influence on measurement result gives chosen pulse sequence and its parameters, such as repletion time and echo-time.

The program "Pulse sequences and scanning methods in MRI", developed by student Boris Sidorov, allows modeling different measurement conditions and to estimate their contribution to some matters signal intensity or tissue contrast at the image. Virtual laboratory contains as theoretical part, as the block, modeling MR-system functioning. Theoretical part includes information about pulse sequence diagram, application field and spin-echo, gradient echo and inversion-recovery pulse sequences features. The practical part contains an array of images (about 120), obtained with MRI-scanners Signa Infinity and Excite HDx (General Electric) in different scanning parameters combinations for studying pulse sequences and allows to estimate technique influence on different tissue (such as white matter, gray matter, water) contrast and measured images signal-to-noise ratio (Fig. 3).
Program interface is quite simple and easy-to-use, and the number of interactive fields and images database could be extended according to application problems. Developed software is used in students education, and also will be helpful for medical staff training.

In some cases it is necessary to perform additional image processing for decision of the problems in field of image reconstruction and improvement, recognition, information compression. Digital image processing is a part of signal processing theory, which main point is signal structure detecting. The most popular instrument for periodical signals analyzing is Fourier transform, decomposing function as a sum of separate harmonical signals. Often Fourier transform used in theory of automatic regulation and control, but distortions influence on spectrum makes it difficult in recognition tasks. Wavelets allow to decompose signal in variable frequency-time window and make easy to analyze non-periodical signals. The wavelet analysis consists of signal decomposition in basis, composed of function with defined properties (wavelet) by applying shift transform and scaling. Resolution and signal-to-noise ratio depend on basis and wavelet character allows to increase resolution inside selected area.

The most of image correction methods are based on algorithms of linear and non-linear filtering. Linear filtering methods are founded on discrete mask and image summing and allows image smoothing, contrast increasing, boundaries detecting. Non-linear filtering produce focusing and erosion effects, removing pulse or Gauss white noise, to realize morphological analysis of the binary images. Processing results are estimated visually or by determining quality factors. Images processing algorithms depend on data type and distortion type (geometrical or intensity distortions, shift, noise).

Different method of approaching to the images processing problem are considered in the other program "MR-images quality quantitative estimation", developed by student Leonid Bartenev. This software allows to process the DICOM 3.0 files, to apply different linear and wavelet filters, to compare processed image with etalon or initial image. The separate module realizes results quality estimation by calculating average means, standard deviation, number of brightness gradation, image sharpness and contrast.

5. Conclusion
In the paper there were analyzed the requirements medical devices consumer to technical specialists, who are able to design separate systems and blocks of the MR-scanner and tuning it, and also to troubleshoot hardware faultiness, to decide applied clinical tasks, to plan
scientific experiments. Every year the number of MRI and CT scanners is increases, so the requirements in high-qualified personal is also increases.

In the department of measurement techniques and computed tomography SPbSU ITMO software and interactive training tests are developed and used in studying, that allow visually demonstrate dependence of measuring algorithm on the result, to simulate different MRI hardware faultiness, troubleshooting, to analyze hardware and technical parameters modern devices. Students get an opportunity to practice on different vendors tomographic devices in Saint-Petersburg clinics, to take a part in science activities including clinical projects. The department is equipped with NMR device, developed by staff and postgraduate students. Specialists development in this field is 20010006 «Tomographic diagnostic methods» (master degree) and in 200101 «Instrument making» field with spatiality «Computed tomography». Technical solutions, considered in this paper, allows to increase not only qualification of the engineers, but will be useful for medical staff.

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References