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Impact of Simulation on MRI Physicists

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Abstract

MRI is a very complex imaging modality in radiography. Although some simulators have been developed for training purposes, we are not sure about any of them. In this research, we tried to measure the performance of different simulations for educational purposes and then quantitatively evaluate them.

With this paper, our study deals with an evaluative review of previous studies related to MRI simulators, which are designed to perform specific functions to help the medical engineer managing radiographic operations to better learn the theoretical and practical concepts of MRI from others. Traditional education, which is a method based on reviewing previous studies, searching for strengths and weaknesses in simulators and possible alternatives to them, and then providing recommendations for future studies that can be conducted to switch to packaging simulation programs,

which are virtual laboratories that we hope will be the most efficient simulation devices and models used. Currently in MRI engineer qualification.

Keywords: C++, C, CUDA, Java, Krubach's Alpha Method, Bloch Equations, Fourier Transforms.

1. Introduction:

Magnetic resonance imaging (MRI) is a non-invasive medical imaging modality commonly used for the diagnosis of diseases related to soft tissues, and significant growth has occurred in recent years [1]. MRI is considered one of the most important techniques because it provides excellent contrast in soft tissues and uses non-ionizing radiation, multifunctional and a lot of image contrasts by adjusting the physical parameters of the device .

This high flexibility needs competence and a deep background of the MRI engineer with the technology they use to improve image quality; The minimum output is the performance of the scanner at the time of training.

Furthermore it, the software installed in these devices poses additional difficulties, even for experienced imaging engineers and radiologists [2]. Also, the software simulation that uses computers for magnetic resonance imaging as an alternative to stereoscopic simulation devices has the purposes of training and scientific research, and there are four types of such software for simulation [3], which are sensors, and devices that explain basic concepts about the principle of magnetic resonance, reference frames, and phase removal and reconfiguration. And those tools allow to change the parameters and determine the results at each stage, and one of its drawbacks is the inability to predict the situation during the clinical work, which is Adobe Flash Player technology. There is another system that works to clarify the principle of magnetic resonance work from the reality of quantum mechanics [4] and it is a program used for educational purposes. There are other devices that simulate some of the functions and features corresponding to a real scanner during magnetic resonance [5], and work to understand the properties of pulse sequences. And specific parameters so that they can be changed and the introduction of manual operating tools. Thus, the difference between both space and image can be seen in the absence of a three-dimensional geometric layout for some sequences. It is known that educational tools take a long time; because of, it is a Java-based application [6], and the similarity with virtual MRI is noted in that it allows the user to add some kind of pathology simulation. It was developed using C++ program, to be a virtual MRI simulator. Many simulations have been proposed for research purposes [7] and continue to develop continuously [8], which is called the full MR simulation, and it performs many functions, such as scaling, the ability to store files, scientific inquiries, etc. In this technique, we find that the field of vision is fully available, while the engineering planning is limited in cases of perpendicularity. It is an application that works with MATLAB as the user interface while you work.

Simulation kernel with C/C++ programs and some CUDA functions are also available during training.

JEMRIS simulation software has been developed [9]; General purpose Enables and applies resonance effects, nonlinear scaling, and provides various coil geometries and other additional effects such as chemical transformation. MPI technology is used for parallel computing.

Although many hardware does not run directly because the simulation kernel is written in C++, and it targets the CPU exclusively. MATLAB software is also used for graphical interaction, although there is no advanced geometry planning. Thus, it was necessary to use arithmetic functions to feed the JEMRIS sequences to real scanners [10] and also act in the flow simulation [11]. The proposal of SIMRI [12] was put forward as a solution to the Bloch equations and also to a number of

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sequences. Parallel programming is also an accompanying graphical linker for 1D signal visualization and 2D rotational evolution. We note the rapid resolution of the MRISIMUL Bloch equations [13] and the development of CUDA functions to represent the heart and blood vessels. There are similar considerations, as PSUDOMRI is concerned with the different structures of the members being loaded programmatically [14]. BlochSolver [15] works with it, which is another solution to Bloch equations that includes additional graphical representations to the evolution of magnetization. As for the simulator that runs under Windows ODIN [16], it depends on other things and takes the form of SPECT / MRI simulation and a design that takes into account pulse operations. It provides Windows with different functions such as setting parameters, configuring sequences on application, selecting slices, and visualizing simulation dynamics. and engineering planning type, but this software does not simulate the procedure used in clinical practice. Therefore, I think it is directed specifically to study the interaction of movement in which sliding occurs. Thus came the need for simulations that focus mainly on magnetic resonance imaging, so the POSSUM device was proposed [17], to simulate resonance functionally and was also used in other fields, such as the study of the phenomenon of diffusion [18,19] or simulated magnetic resonance angiography [20]. Experts have developed an MRI simulator [21] that allows engineers to mimic a routine MR workflow.

From the above, it can be said that the simulators focus on clarifying specific features about the magnetic resonance phenomenon, also note the repetition of steps taken by the radiologist during daily practice, ignoring spatial planning. A simulator with a smart learning system supported by manual guidance has been implemented, which I believe will be of high training value [22].

There is a great ambition among scholars and experts, to find an educational simulation program that can be run over the Internet, that can be managed without the need for installation, with platform independence. This system will update the sensors and thus depends on web technologies and deals as an educational tool, and is characterized by speed as the image quality is affected.

2. Method and Methodology:

It is essential that the MRI simulator is designed for you. It helps to achieve the requirements of experience, professionalism, and competence in the performance of the radiological imaging engineer and radiologists in a way that serves the routine work in the future.

Also, this type of study supports the engineer with theoretical information and practical concepts in a better way than traditional teaching. In this part of the paper, we describe the materials and methods used to achieve this goal, and provide a brief overview of the MRI simulator described in [21]; Due to our belief that it is an ideal device to a large extent and has many features as it is designed for training purposes and has the approval of experts and radiologists, and Radiographic engineers and trainers.

Beginning by simulating the images created during the acquisition sequences that make up a particular method, he is able to continue to create and implement.

The protocols when locating the patient, give the user the possibility to change the basic acquisition parameters, such as TE echo time, repetition time TR, angle of inflection, inversion time TI and other information necessary in clinical work. And in this device, we notice the possibility of embedding engineering planning during the simulation workflow, from the chip orientation to determine field of view, slice thickness, and selection of phase/frequency coding directions.

It also ensures that changes are made in the k-space as directed by the trainer, and supports different instructional roles, allowing trainers to create multiple programs.

Scenarios to work on and record more results. A non-functional disadvantage of this system is that short simulation times are required for the action/interaction to be acceptably feasible during training.

In fact, it is essential that the system be easy to access/install and able to work on a wide range of platforms.

The system must avoid all parsing operator properties and use the sequences associated with them. Thus, we find that there is a necessity to identify the best methods of structural design and implementation techniques that must be available in the simulation model, so that it consists of evaluation tools for mathematical variables and well-known sequences that operate in a regular sequence when changing parameters in the program interface, and through it, the imaging engineer identifies the sensors and do more responsive experiences. For ease of access and installation, a web-based application can be chosen. so that the system is modeled according to the architecture of what happens in the real-world MRI lab, which is what allows the Representational State Transfer (REST) application program interface (API) to use the Django framework [23]. and when the simulations are implemented with C++; Interaction is achieved with the static file service and the authentication service [23] Where data and simulation base.

It acts as a graphical interface that the user of the files can use to perform simulated actions. The selected geometry parameters can be manipulated such that the image contrast is simulated by evaluating known algebraic expressions corresponding to the sequence chosen by the user [25, 26]. and by applying Fourier transforms to the contrast image, resulting in what is called a k-space. In this space, a number of pieces captured from the simulation can be obtained easily, and the latest examples that we can give here are the kinetic effects, height, or noise generated by thermal energy. Comparing the features that should be available in simulation programs and different models with the experiments conducted on magnetic resonance imaging engineering students, which were based on determining the level [27], by means of a technical measurement tool [28], and using Cronbach's alpha method [29] to approach expectations. , from statistical information such as median, mean, standard deviation, and effect size calculated [31] for descriptive analysis.

3. Conclusions:

In terms of reliability, correlation analysis can be done to compare between stereoscopic and software simulations with the aim of obtaining information that would provide us with the reliability of those systems [32].

We note that the simulator described in the reference [21] is the closest to achieving all our aspirations in training and education, and we expect that it will be more widespread in the field of research, and the most demanding [33] and reliable for training MRI engineers and technologists when it comes to applying the concepts practically. Insightful, there are inconclusive points, as the software works with more focus on the theoretical side and we need a long time to run additional programs corresponding to the sensors, however, we expect that this program will be developed to run on online platforms. We will also notice more positive results in the references [21,22].

We need conclusions aimed at laying scientific and technical foundations for a long-term simulation that serves the purposes of training positively and effectively, and that this simulator deals with complex ideas, so the simulator should show interfaces similar to the real laboratory.

In this work, we have presented an evaluation of a computer-trained MRI tutorial.

It is a simulation model based on a number of functional and non-functional requirements and signals. That compares simulation performance with the traditional educational approach, educational assessment leads us to the field of application that has been described in the literature, so our attempt appears to be the first attempt to shed light on this important topic. Our results show that such a learning tool leads to an improvement in applied learning outcomes, so we conclude that simulation is indeed a useful method for dexterity gains in the MRI process that deserves attention.

Through the literature reviewed in this paper, we found that medical simulations, whether stereotaxic or computer programmed, allow the acquisition of clinical skills through practice rather than the traditional learning method for MRI engineers. It has been proven that training has many advantages that help improve the efficiency and performance of the medical practitioner, and in return, improve the diagnostic and imaging processes to serve patient safety and reduce health care costs.

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