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DIGITAL TECHNOLOGIES AND VIRTUAL REALITY TOWARDS THE INDUSTRIAL RADIOGRAPHY SIMULATOR IMPLEMENTATION

Abstract

The article deals with the problem of the implementation and practical usage of software solutions based on virtual reality technology in the fields of training, retraining and advanced training of industry specialists in radiography nondestructive testing. The comprehensive multi-component approach to the creation of the training environment proposed by authors is presented. The main components, their goals and tasks are considered. The physical and technological aspects are investigated, modeling, algorithmization and software implementation of the VR simulator are performed. The main directions of solution development and scaling are listed.

Keywords: digital and information technologies, virtual reality, software simulator, industrial radiography, X-ray image

Nowadays computer technologies have proven to be a useful tool in education. With the development and spread of computing, information and communication technologies, as well as the growth of computer literacy among the population of different age groups, digital educational technology has also developed. World practice shows that the use of information technology and digital technologies is relevant in personnel training both in professions involving communication with people and in professions requiring monotonous operations and in professions involving smart manufacturing.

Among the digital technologies in education virtual reality can be distinguished. Digital simulators on the basis of these technologies allow expanding the list of tasks solved in training and the quality of learning material in various areas due to a deeper involvement of the learner in the studied material and scenario with the involvement of visual, auditory (auditory) and motor (motor) memory. The above-mentioned allows us to note the potential of including VR technologies in the training program of technical specialists for professions associated with danger and high requirements for professionalism of employees.

Today, there are different VR systems in terms of their architecture, functional content, complexity, and cost. At the same time, there are solutions for distance education in digital radiography offered, for example, by the American Institute of Non-Destructive Testing. However, they do not use hardware and software solutions of virtual reality and artificial intelligence elements in the training and knowledge-checking of non-destructive testing specialists.

Radiation testing (RT) is one of the most widespread types of nondestructive testing (NDT) in the spheres of machine-building production and power engineering. In this regard, the radiation type of nondestructive testing with the radiographic method of obtaining source information, as one of the most demanded and widely used in industry, was considered a priority in terms of education in the VR environment (Fig. 1).

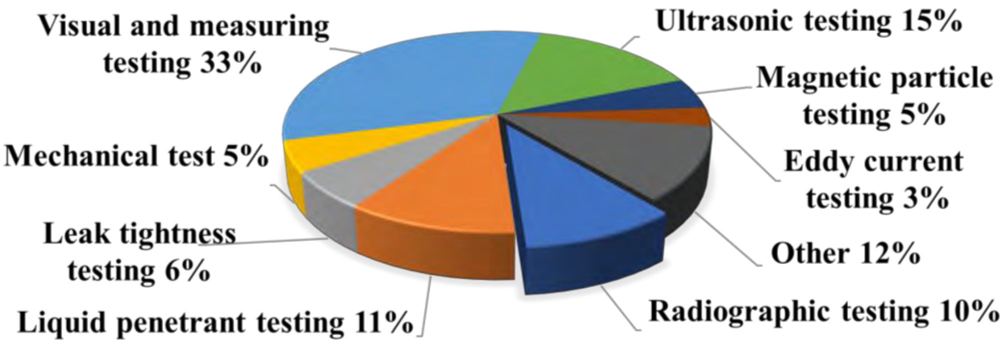

Fig. 1. Percentage of specialists certified in various types and methods of nondestructive testing and other tests

In the nuclear power energy industry, the most important type of inspection is the radiation type. Compared to visual and measuring testing methods, as well as ultrasonic testing, radiation types use ionizing radiation that is extremely dangerous to others. In combination with the fact that the inspection often has to be executed at the place of communications installation, the actions of X-ray and gamma-ray defectoscopists carry more threats to human health and the environment than other inspection methods.

At the same time, it is difficult to organize a comprehensive amount of practical training for future defectoscopists. Due to the high time and resource costs for accreditation and maintenance of training laboratories and the lack of training grounds, there is a shortage of practice, which is an important part of the educational process. Application of the virtual environment at the stages of the introduction to the equipment and stages of the technological process of X-ray and gamma-ray inspection, as well as at knowledge checking, will reduce training costs, simplify access to practical training, and, in a safe way, increase the throughput capacity of training centers.

Within the framework of the digital NDT virtual simulator, digital twins of key technological process elements are considered independent educational resources and are subjects of research for specialists: defectoscopists and technologists. In the context of the radiation laboratory, one of the key objects of study is undoubtedly the image obtained during RT using a radiograph. Fig. 2 shows the entity relationship diagram for the simulation process of radiographic image digital twin generation. It illustrates the relationships and parameters of digital twins that are part of this complex educational resource.

The combination of multiple digital twins produces enough data to generate a simulated X-ray image twin using a 3D engine for the linear algebra transformations.

Important parts of the practical professional activity of defectoscopists are both the ability to adjust the testing parameters to changing conditions (work in a limited space, different nomenclature of detectors, and other differences) and the ability to correctly and safely manually set up all the instruments and settings and execute exposure. During the sessions, trainees place the RT machine in the correct position relative to the testing object, perform markers' assembly using available symbols, place sensitivity indicators and markers, tags, and other auxiliary technological equipment. In the case of film detector training, students make settings for the development process in a special room. The resulting radiogram quality is checked at the end of the equipment stage. For this purpose, the transparency property of the film detector digital twin is analyzed. Using a negatoscope device with adjustable brightness, the densitometer is adjusted, and the optical density and contrast of the obtained image are checked.

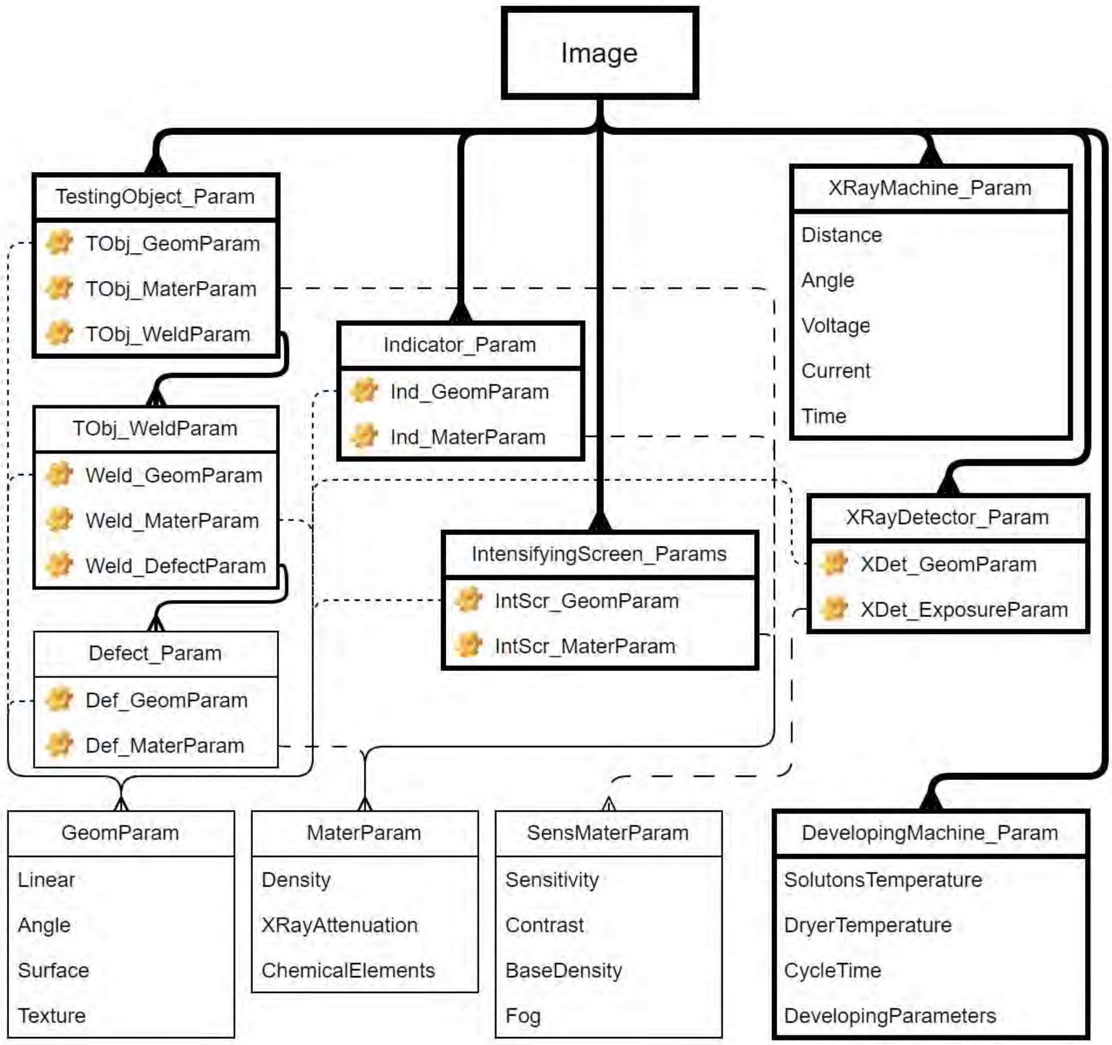

Fig. 2. ER-diagram for digital twin of radiographic image generation

The complex of digital twins, which are educational units, forms a composite educational resource: a VR radiographic laboratory simulator shown on Fig. 3. Along with the manual method of defect detection on a radiographic image, as part of its processing, it is possible to use smart software tools. The software, using the mathematical apparatus of artificial neural networks and deep learning as its basis, is used for the computer interpretation of radiographic images of welded joints in metal structures. This solution is designed to reduce the influence of human factors on the interpretation of radiographic images through the automation of operations for defect detection and classification and to increase the speed and accuracy of measurement operations. One of the main issues is that deep learning models require a large amount of data to be effective, which can be difficult to obtain in some fields, like NDT. The development of a sufficiently accurate tool for creating a digital twin of an image with given exposure parameters can significantly affect the quality of training for classifiers, including those based on artificial neural networks.

Fig. 3. VR simulator of industrial radiography, 3D-view

Practical usefulness of development of digital educational environment can be fully revealed by scaling the obtained solution to related types and methods of nondestructive testing: visual and measuring testing, liquid penetrant inspection, ultrasonic testing, eddy current testing and others.

The high mobility and availability of virtual reality system equipment are combined with the possibility of distance learning at the early stage of the training program using digital resources. This opens up improved opportunities for providing the nuclear power industry and other industries with new qualified specialists by implementing access to educational resources at industrial enterprises and affiliated higher and secondary educational organizations. Further improvement of the quality of radiogram digital twin simulation within industrial radiography simulator environment has powerful potential for application to machine learning and deep learning tasks by enriching training example sets and reducing sparsity in the training data.

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