USE OF RAY TRACING ALGORITHMS FOR DOSE CALCULATION IN THE VIRTUAL ANALOG OF THE IRT MEPhI REACTOR

Azizov Sh.M.

expert of the State Ecological Expertise, Tashkent

Kiryukhin P.K.

Engineer, Department of "Theoretical and Experimental Physics of Nuclear Reactors",

NRNU MEPhI, Moscow

E-mail: cproangel@gmail.com

Abstract

This work is devoted to the development of a system for estimating neutron radiation dose loads for the virtual analog of the IRT MEPhI nuclear reactor. This system is implemented based on ray tracing algorithms and is designed to simulate the distribution of dose loads in real-time at any point behind the reactor shielding [3, 4]. The aim of the project is to create a safe and accessible platform for training students in nuclear physics and nuclear reactors, within which the interaction of particles and shielding layers is simulated without the need for access to the experimental facility. This approach not only improves the level of training for young specialists but also provides an opportunity to study the physics of radiation processes more deeply by visualizing key aspects of the interaction of neutrons and gamma radiation with the materials of the reactor's protective screens.

Keywords

Virtual analog, nuclear reactor physics, radiation protection, Unreal Engine, IRT MEPhI, Ray Tracing.

Thesis

The article presents a comprehensive approach to calculating neutron radiation dose loads in a virtual model of the IRT MEPhI nuclear reactor, developed on the Unreal Engine platform and utilizing ray tracing algorithms for modeling and visualizing radiation processes. The main goal of the development is to create a system capable of calculating dose loads behind the reactor's protective barriers in real-time, which has significant educational value for students studying the physics of nuclear reactors. The implementation of a virtual environment allows for the recreation and study of the behavior of radiation fluxes and their interaction with shielding materials, enabling safe simulation of real processes without direct exposure to radiation.

The software platform is built upon ray tracing algorithms, which allows for accounting for the direction and intensity of neutron fluxes, modeling their interaction with shielding materials, and obtaining data on secondary gamma radiation arising from neutron absorption. The system implements a two-way communication mechanism with the virtual reactor control interface via the UDP protocol:

data on control rod movement and changes in reactor parameters are transmitted in real-time, ensuring high accuracy in dose load calculations. The program processes this data by solving diffusion equations to calculate changes in reactor power and their influence on neutron fluxes. The obtained reactor power values are used for subsequent dose calculations, making the model highly interactive and adaptive to parameter changes.

This approach not only solves the problem of safety and accessibility of training for students but also allows for a more detailed study of the physics of particle interaction processes in nuclear reactors. The system provides the opportunity to observe the distribution of the radiation field in various reactor zones, analyze changes in dose loads depending on rod positions and reactor power, and account for secondary gamma radiation. The use of a virtual model built on Unreal Engine (Fig. 1) enhances the educational process by providing students with the opportunity to immerse themselves in the practical investigation of complex physical processes with precise visualization [1]. Such a model can serve as an important educational tool, expanding the capabilities of traditional experimental facilities through virtualization and the active use of simulation technologies [2].

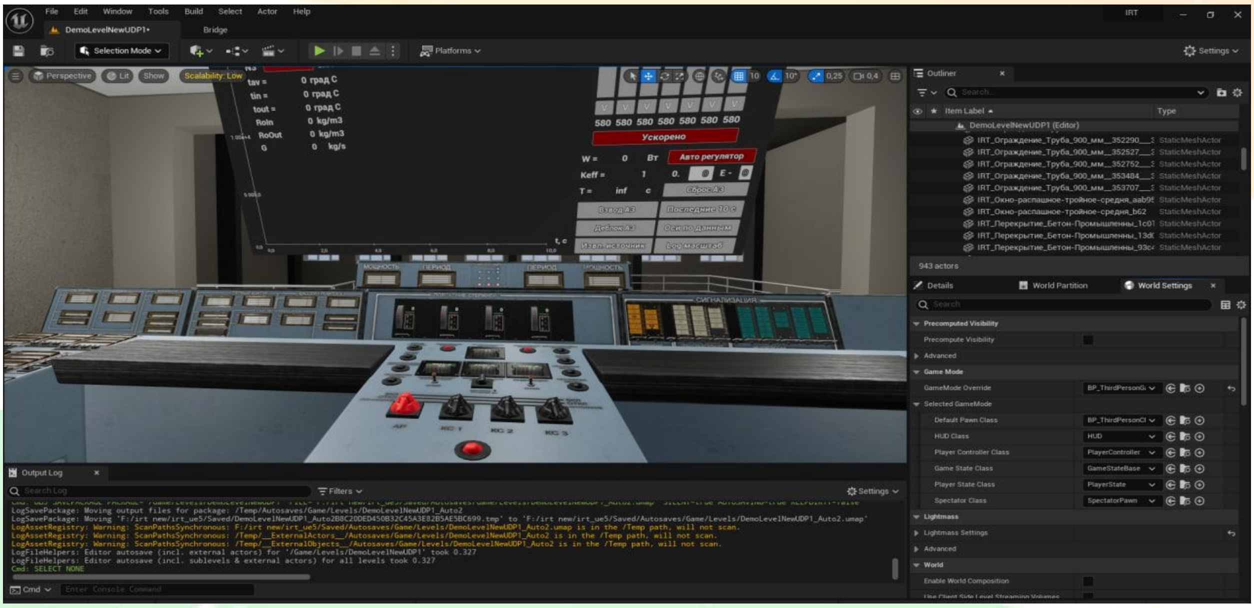

Figure 1. IRT MEPhI control panel in Unreal Engine

References

1. García-Hernández R.J., Kranzlmüller D. NOMAD VR: Multiplatform virtual reality viewer for chemistry simulations.

2. Afanasyev V., Kryuchkov E., Petrov V., Saldikov I., Ternovykh M. “Concept of development and use of virtual laboratory works on unique experimental equipment in the field of nuclear power installations”. *Vestnik of the National Research Nuclear University MEPhI*. 2012. 1: 111-2.

3. Unreal Engine. https://www.unrealengine.com.

4. Gusev N.G., Klimanov V.A., Mashkovich V.P., Suvorov A.P. “Physical foundations of radiation protection”. Moscow, Energoatomizdat, Vol 1. 1989.