A Study on Radiation Risk Recognition Aided System Visualizing Risk Information by CG

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Abstract: The technology of Computer Graphics (CG) has been in great progress for almost 20 years and has proven to be a valuable tool for a broad variety of fields, including nuclear engineering. To work in any hazardous environment for example radiation field is particularly challenging because the danger is not always visually apparent. In this study as the application of CG to nuclear engineering field, we proposed to develop a radiation risk recognition aided system in which various radiation information; radiation risks, radiation distribution, hazard information and so on, were visualized by CG. The system used the server and client system. In the server there were two parts; one (main-server) was the database part having various data and the other (sub-server) was the visualization part visualizing the human phantom by POV-Ray. In the client there was the input and output part. The outputs from the system were various radiation information represented by coloring, circle graph and line graph intuitionally. The system is useful for a broad range of activities including radiation protection, radiation management, dose minimization, and demonstration to the public

1. Introduction

CG technology has been great progress for almost 20 year with improvement on computer-generated environments and has proven to be a valuable tool for a broad variety of fields. To work in any hazardous environment for example radiation field is particularly challenging because the danger is not always visually apparent. Proper visualization of these dangers must be provided on selecting sensible way of reducing risks and high recognition against risks to the people. The development of a radiation management system by visualizing health risks from ionizing radiation using CG [1] is applications making the most use of the improvement on computer and CG technology.

In radiation protection, our previous work [2], we obtained the radiological protection quantity for high-energy electron radiation. Since the radiation management system has used numerical expression so far, it has been difficult for the public to understand the system.

This study proposed to develop a radiation risk recognition aided system as an application of CG to nuclear engineering field. In this system various radiation information; radiation risks, radiation distribution, hazard information and energy deposition to the body, were visualized by a colored phantom, graphs, texts and so on. By visualizing radiation information the user can understand easily their radiation risks.

2. Calculation of Radiation Information

In radiation protection, by taking account of new biological information, The International Commission on Radiological Protection (ICRP) recommended the system of radiological protection and the radiological protection quantity as safety standard [3]. We carried out in our previous work EGS-4 Monte Carlo simulation code using an MIRD-5 mathematical phantom to obtain the radiological protection quantity for high-energy electron radiation, which is not supported sufficiently by ICRP yet.

The Electron Gamma Shower 4 (EGS-4) Monte Carlo code [4] has been widely used in the field of medical physics to study such phenomena as electron contamination by photon beams. In the computer, we built up an MIRD-5 mathematical anthropoid phantom [5], which was first developed for calculation of internal exposure dose. The shapes of the body, organs and tissues are represented by combinations of numerical formulas and almost all of the shapes are quadratic polynomials. Due to the limitation of usable numerical formulas, the shapes have been idealized and are comparatively simple. Furthermore, due to visualize the radiation distribution, we built up the geometry of a facility in the EGS-4 code and simulated the radiation spatial distribution (for gamma ray) in that geometry.

3. The outline of the system

2.1 Virtual geometry and visualized phantom

The user could see the radiation distribution from EGS-4 simulation output data using a virtual geometry. Figure 1 showed the virtual geometry with radiation distribution expressed by colored spheres. The color of sphere was defined by the simulated value of radiation fluence. In this study we adopted blue as low value of the fluence and red as high value, and the color was changing from blue to red in proportion to increasing the value like Figure 1. In the virtual geometries he could move his position, walking route and the stay-time on his point using mouse operation. For each worker and work task, radiation information (exposure dose, energy deposition) was computed and stored to the database.

In order to express the radiation energy deposition or radiation risks to the body it is necessary to visualize a

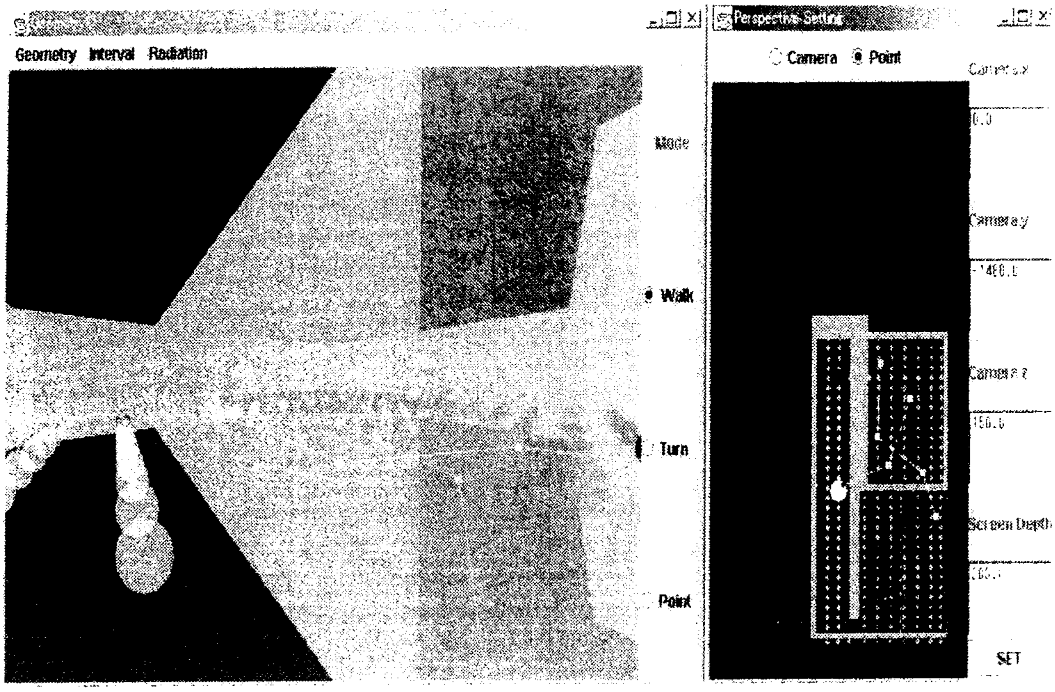

Figure 1. The virtual geometry with radiation distribution simulated by EGS-4. User could move front-back, left-right and up-down by mouse easily, and he could inputted his walk through path and time at the point.

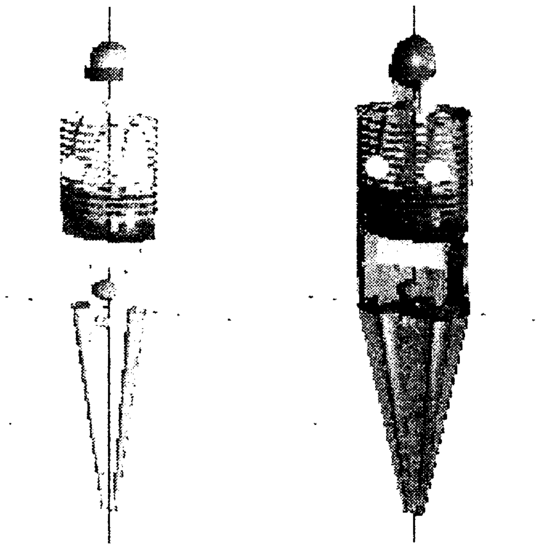

Figure 2. The human phantoms made by POV-Ray; the whole body with specific organs (left) and the whole body with transparency material (right)

human body. In the present study, Persistence of Vision Ray Tracer (POV-Ray) [6], a software program for creating three-dimensional graphics by ray tracing, was used to three-dimensionally visualize the exterior and important internal organs of the human phantom. Due to know the risk of specified internal organs the exterior and organs were expressed by transparent material. The user could select various phantoms for their risk recognition, for example, changing the viewpoint, displaying the cross section and some organs in the phantom.(See Figure 2

2.2 The architecture of the system

The radiation risk recognition aided system could be divided roughly into server side and client side. Figure 3 showed the flowchart of each task in the system.

In the server, there were two parts; the database part having various data and the visualization part visualizing the colored human phantom by POV-Ray. In the database part, there were five different type data as follows;

1. Simulation Data; simulated radiation data including the radiation distribution by EGS4 and the radiological protection quantities by ICRP for neutron and photon, and by our results for electron
2. Exposure situation; radiation source energy, source kind, and calculated individual exposure dose which were used in the virtual geometry
3. Facility Data; working geometry and safety rules of each facility
4. Image Data; CG image data made by the visualization part (by POV-Ray)
5. Explain Data; explanation data including radiation hazards based on the radiation medical science

In the client, there was the input and output part. In the input part, a user inputted some information on the worker (name, sex, ID number, age, and category), on the source (kind of radiation, energy), on the exposure situation using the virtual geometry and on the output demand (select

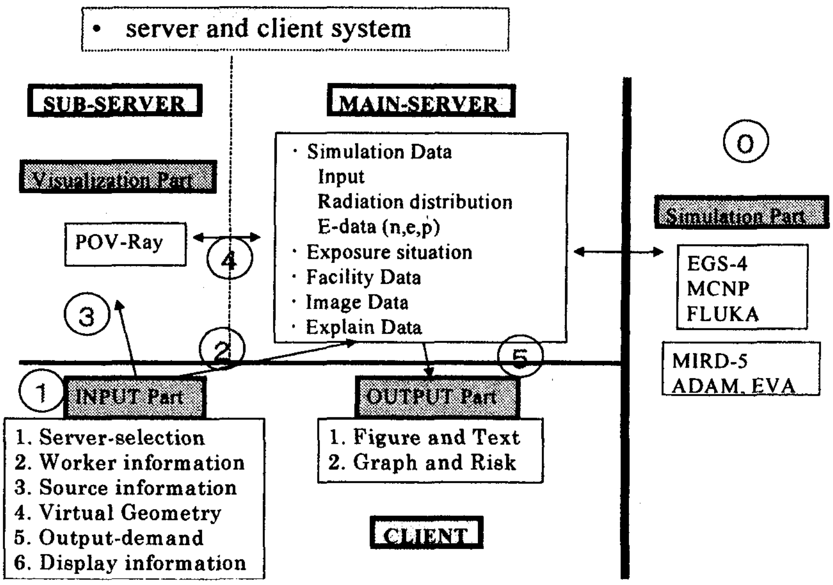

Figure 3. The flowchart of each task in the radiation risk recognition aided system. The system had two parts in the server and the input and output part in the client.

organ for output, viewpoint, and cross section). Based on the output demand data, the sub-server started POV-Ray to create the risk colored phantom and then sent this result to the image database in the main-server. The main-server sent the required radiation data to the client and at last the output part displayed the useful information to the user.

4. Results

The examples of output part were depicted in Figure 4.

It is very important how the risks are expressed in the system because the system helps the public, who don't have any knowledge of radiation protection, recognize easily the risk information. Therefore, the system had following features.

(1) The coloring expression for high recognition about risks: In this study the coloring expression was used in the phantom image, the risk information panel and the virtual geometry due to recognize radiation risks by intuition. Especially the blue was adopted as the 0% or as the small value and the red as the 100% to the radiation risk for whole body or as the large value. By changing the color in proportion to the risks, it was easier to recognize the risks.

(2) All information was displayed in output part at the same time: The system displayed in the output part as follows; colored phantom by risks, hazard information in text, line graph plotted radiation protection quantities for each organs, risk information panel showed the ratio of the each organ dose to the year limit dose of whole body risk and circle graph expressed organ contribution for whole body risk. In the line graph there was a vertical line that showed the energy a user selected in the input part. The risk information panel and the circle graph expressed the risk situation when the source energy was the vertical line. It was possible that the vertical line was moved by changing the slider. So they could obtain the risk situation of various source energies. Furthermore like Figure 5 all information was showed at the same time, so they could discuss those results each other and know the hazard situation around them without researching any books.

(3) The use of virtual geometry: If a user used the virtual geometry before he entered the radiation field or started the task in the real world, he could know his individual radiation dose or the risk situation of his working area. That information helped him to receive good communication about radiation and plan his work task with as low radiation exposure as possible.

5. Conclusions

In this study, as the application of CG to nuclear engineering field, we proposed a radiation risk recognition aided system in which radiation risk information and radiation spatial distribution were visualized by CG technology and the coloring expression. Visualizing hazardous environments and risk information helped the user know the risk situation around him by intuition and make a good decision (selecting a sensible way of reducing risks) for his task in the real world quickly. Furthermore, because of the pre-information about the individual radiation dose and risk the users will be able to reconsider their project or working efficiency. The system is useful for a broad range of activities including radiation protection, radiation management, nonproliferation, nondestructive assay, waste management, dose minimization, and demonstration to the public and space exploration.

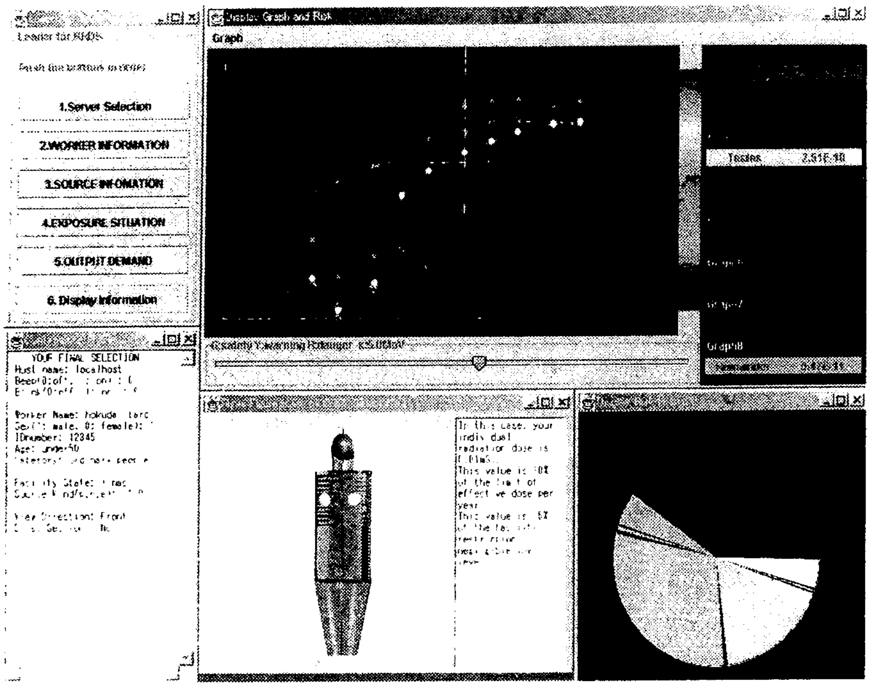

Figure 4. The output part in the system. The leader panel, confirmation panel and various output data; line graph plotted radiation protection quantities, risk information panel, colored phantom by risks, hazard text and circle graph expressed organ contribution for the whole body risk.

Issues for future study include the expression methods and the display layout avoiding wrong recognition, the improvement on database and the possibility of the system serving to the people anytime and anywhere; supplying by WWW or mobile system. It is also needed to practice experimentally in radiation field like accelerator facility and to discuss the evaluation of the system.

References

[1] M. Katagiri, M. Hikoji, M. Kitaichi, S. Sawamura and Y. Aoki, "A STUDY ON A RADIATION MANAGEMENT SYSTEM VISUALIZING HEALTH RISKS FROM IONIZING PARTICLES BY CG TECHNOLOGY", *ICIP2001*, Vol.1 pp.301-304, Thessaloniki (Greece), 2001

[2] M. Katagiri, M. Hikoji, M. Kitaichi, Y. Aoki and S. Sawamura, "Effective Doses and Organ Doses in the MIRD-5 Phantom Exposed to Monoenergetic 0.1 MeV to 200 MeV Electrons in the LAT Direction", *Radiat. Prot. Dosim.* 95(2), pp. 149-156, 2001

[3] The International Commission on Radiation Protection, *Conversion coefficients for use in radiological protection against external radiation*, ICRP Publication 74, 1996

[4] Nojiri, I. Fukasaku, Y. and Narita, O. "Application of a general purpose user's version of the EGS4 code system to a phantom skyshine benchmarking calculation", *L1349A KEK Proc.*, No.94-8, pp. 59-68, 1994

[5] Walter S. Snyder, Mary R. Ford, and Gordon G. Warner; "Estimates of Specific Absorbed Fractions for Photon Sources Uniformly Distributed in Various Organs of a Heterogeneous Phantom", *MIRD Pamphlet No.5, revised, Nucl.Med.*, 1978

[6] The Persistence of Vision Raytracer Web page: http://www.povray.org/