Datavisulization and Photorealistical Infrastructure Computer Graphics

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Abstract – The report discusses the benefits of incorporating photorealistic computer graphics and data visualization into IT education. The practical application of the beam tracking method in different scientific fields is discussed. The described approach is illustrated by the experience gained during the facultative "Ray Tracing - photorealistic imagery" event.

Index Terms – Computer graphics, ray tracing, training, informatics.

1. INTRODUCTION

Data visualization is an area where in-depth research has been carried out for many years. The area is generally complex and profits intensely from complex mathematical apparatus. Whether it's visualization of mathematical surfaces, molecules, design automation, entertainment software, multimedia, animation films, all of these are activities inherent in computer graphics.

It is a complex and diverse piece of informatics that is particularly relevant to research over the past twenty years. These studies have led to the creation of a number of informative models, the rapid development of specialized hardware and the establishment of new educational paths. Visualization methods are one of a number of areas in the field of computer graphics [1]. In general, we can consider it as a set of the following units:

- Geometric modelling: methods for describing and presenting the geometric shape of scenes (two-dimensional and three-dimensional) and their processing by the applied software.
- Generation of images and photorealistic images: algorithms and methods for displaying objects, creating realistic pictures with different optical effects, lighting, coloring and others.
- Graphical interaction: methods for organizing human-computer communication using visual means.
- Perceptual computer graphics: the observer's perceptions are studied, abstract models and links between them and the objects in the scene.
- Computational geometry: Algorithms for solving geometric combinatorial tasks.
- Image Analysis: Image Assessment, Image Recognition.

2. MOTIVATION

In the basic computer science training course, the subject of Computer Graphics, besides the theoretical training, which is gained from the lectures, the emphasis is on the practical construction of a geometric modelling system [2]. The system is built using modern programming environments and object-oriented C #, C ++, Java, Object Pascal languages. Practical design templates such as Model-View-Controller are practiced. Graphics libraries are used for the development, focusing primarily on designing a user interface (GUI) and creating and manipulating parameterized geometric objects.

In developing the visualization module, students learn to use standard graphical libraries, such as OpenGL, which allows them to concentrate their work on the scene model. On the other hand, standard APIs have limited visualization capabilities of geometric primitives and use mostly a local illumination pattern. This prevents the student from getting an in-depth practical idea of the process of generating images and simulating physical phenomena such as reflections, transparency, global illumination, and more.

In order to fill this gap, three years ago, an optional Ray Tracing course was introduced. The course is aimed at studying the behaviour of light in nature and creating a mathematical model. In the practical part, the students acquire the skills needed for the software design of a framework library framework and the realization of the mathematical model of light, building on the framework. The realization is based on the ray tracing method.

PC illustrations are pictures and movies made utilizing PCs. For the most part, the term alludes to PC produced picture information made with the assistance of particular graphical equipment and programming. It is a huge and as of late created region of software engineering. The expression was instituted in 1960, by PC designs analysts Verne Hudson and William Fetter of Boeing. Usually abridged as CG, however now and again incorrectly alluded to as PC produced symbolism (CGI).

The term PC designs has been utilized in an expansive sense to portray "nearly everything on PCs that isn't content or sound". The investigation of PC designs is a sub-field of software

engineering which contemplates techniques for carefully integrating and controlling visual substance. In spite of the fact that the term regularly alludes to three-dimensional PC illustrations, it likewise incorporates two-dimensional designs and picture handling.

As a scholastic control, PC designs ponders the control of visual and geometric data utilizing computational methods. It centres around the scientific and computational establishments of picture age and preparing instead of simply tasteful issues. PC designs is frequently separated from the field of representation, despite the fact that the two fields have numerous likenesses.

3. THE METHOD OF TRACKING

In the huge area, frequently photorealistic graphical systems are creeping in industry method on the trace of the graphics. In the meantime, let's describe the mechanism to work, just base component [3]:

- Sensor / Camera: model on the observer on the stage;
- Scene: from the geometry, describe the reality;
- Light Sensors: the light energy of pre-scenes of the sensor is extracted;
- Extreme image: a model on the goods as a sensor of visibility for light stone Energy;
- Material: the model for visual characteristics on the date of the surface.

The image is viewed as a set of multiple pixels. A beam is created, starting from the observer's position and passing through an element lying in the plane of the image. The beam is checked to see if there are intersections with the objects on the scene. If intersections are more than one, the closest point to the observer's position is the result of the intersection. Then the color and geometric characteristics of the object at the point are established and the resulting color is recorded in the given element of the final image. The algorithm provides an immediate solution to the problem of removing invisible surfaces in the scene and the problem of discretization of the geometric object on the plane of the image. Ray tracking has a very important advantage over the raster algorithms used in libraries like OpenGL, it does not impose limitations on the type of geometric primitives it can depict. The only condition the object has to meet is to know how to cross it with a beam. Figure 1 schematically shows the process of tracking rays in a scene.

To be able to simulate different physical phenomena such as reflection, light refraction, different types of materials (eg wood, concrete, metal, etc.), each object should contain a description of the material composing it. The material determines the amount of light energy reflected from the surface that the observer will reach. It also determines the direction in which the beam will be reflected. The patterns of light surface interaction are well parameterized to be able to simulate a variety of materials from the real world. Radiation tracking combines calculations by calculating the visible parts of the objects and the illumination of the scene. For example, shadows are calculated as part of the energy that reaches (visible) from the light source to a point on a surface, the mirror reflection, respectively, is the energy obtained from the visible surfaces in the direction of the reflected beam. This is a huge advantage of this method of rasterization. This allows us to simulate the effect of global illumination where light is transmitted indirectly between the objects in the scene without having to make any changes to the modelling and realization method.

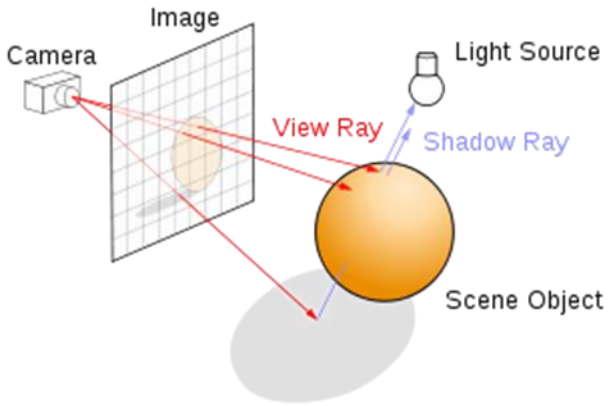

Figure 1: RayTracing Diagram

4. RAYTRACERGRAPHIC FRAME

The main objective is to acquire practical skills in the development of tools for generating photorealistic images. This is achieved by giving students a basic realization of the RayTracer graphics framework prepared in advance for the purpose of the course. It implements the basic infrastructure of the algorithm for tracking the rays, the individual stages of the algorithm are separated meaningfully as different modules. The main features of the system are:

- Openness: the possibility of extending the system in one or more directions.
- Modularity: clear identification of components as independent software units.
- Distributing: simultaneous work of parts of the application of different artists.

The architecture selected strongly emphasizes modularity (plug-in). This helps right from the start, to get a clear idea of the stages of image generation. The architecture also supports the gradual build-up of graphic application. Poor connectivity also allows several developers to work on different modules,

which encourages teamwork and leads to more sophisticated visual results for students with a keen interest in the graph.

5. ANNEX

The application that has RayTracer can be summarized in the following directions: learning, research, application. Some of his possible apprenticeships in the training are:

- Illustration of study material by visualization of volumetric models in various fields. (mathematics, biology, chemistry, physics, informatics, etc.)
- Practical experience with plug-in software architecture.
- Developing applications in the field of generic computer graphics [4].
- Studies on new algorithms for approximate lighting calculation [4].
- Design and implementation of distributed application.
- Moving the graphics frame onto different hardware architectures [5].

Concrete disciplines in IT education can also benefit greatly from RayTracer's application in the learning process:

- Linear algebra and analytical geometry: visualizing different surfaces and working with vectors and matrices.
- Differential geometry: study of the geometric properties of the surface at the point of intersection with a beam.
- Numerical methods: Visual illustration of Monte Carlo methods for lighting calculation.
- Distributed applications: the very nature of the beam tracking algorithm enables calculations to be performed in parallel, different parts of the image can be computed by different artists.

RayTracer can successfully be used in the development of diploma thesis.

6. CONCLUSION

Photorealistic graphics have entered our lives in the last few years, through computer-generated films and commercials [6]. The topic is very topical and the leading cause of constant innovations in specialized hardware. For this reason, the subject studied in the course gives the trainees new practical knowledge in line with market requirements. In addition to illustrating and reinforcing the knowledge gained in the study of classical disciplines, the knowledge and skills accumulated in the development of the toolkit will be beneficial to prospective employers. In the future, the improvement of the awareness of students about the benefits of studying the area of photorealistic computer graphics and the formation of even more specialized courses for advanced students, working with specialized graphics hardware and generating real-time photorealistic images, hopefully will be achieved.

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