CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

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Project Number

S1811

Project Title

Relativistic Ray Tracing: Using Ray Tracing to Simulate the Appearance of Objects in Relativistic Situations

Abstract

Objectives/Goals

The goal of the project was to determine whether ray tracing is an effective method of visualizing relativistic physics.

Methods/Materials

A basic Java ray tracer was written using the Eclipse IDE on an Intel quad core i7 laptop, upon which relativistic transformations for both special and general relativity were applied. The resulting program was then run on a variety of test scenes, and the resulting images were analyzed. Computation times for the multithreaded ray tracer were compared with those of a single threaded approach, and were anti-aliased and aliased versions of the ray tracer were compared as well.

Results

Implementing multithreading and antialiasing into the ray tracer cut computation times by approximately 50% while increasing overall image quality, particularly around the edges of objects. The images produced under both special and general relativistic conditions demonstrated a wide range of relativistic effects, including the Lorentz transformation, relativistic aberration, and gravitational lensing. Moving towards scenes at relativistic speeds typically resulted in an increasing field of view accompanied by the shrinking of objects, whereas moving away from scenes at relativistic speeds resulted in a decreasing field of view and the enlargement of objects. The addition of gravitational lenses into scenes allowed for the visualization of various optical effects caused by gravity.

Conclusions/Discussion

Ray tracing demonstrated great success at providing a means to visualize scenes under relativistic conditions. A ray tracer built from scratch in Java and run on a home laptop was capable of rendering a diverse variety of scenes implementing both special and general relativistic effects. Images produced by the ray tracer were physically accurate, excluding inaccuracies caused by the use of the gravitational lens approximation, and rendered within relatively short amounts of time with the addition of multithreading. In conclusion, the ray tracing proved to be an efficient, capable, and accurate method of visualizing relativistic physics.

Summary Statement

This project applies the computer graphics technique of ray tracing to visualize the appearance of objects under special and general relativistic conditions.

Help Received

Dr. James Li served as a mentor for the project and provided guidance on the general direction of the project, including the extension into general relativity after special relativity. Mr. Tim Smay also helped structure the final research paper and edited some parts of this report.