ARMY RESEARCH LABORATORY

Uniform Tests of File Converters Using Unit Cubes

by Steven J Nichols

ARL-CR-0770 **March 2015**

Under contract

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Disclaimers

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Aberdeen Proving Ground, MD 21005

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14. ABSTRACT
Ballistic Research Laboratory–Computer-Aided Design (BRL–CAD) is a solid-geometry modeling system used to design and develop geometric systems. It employs a sophisticated ray-tracing software system to evaluate materials, perform calculations, and render images of models of US Army vehicles. Ray-tracing large geometries could require millions of floating-point operations. Also included in BRL–CAD are converters that allow the user to convert from different geometry file types. The goal of this project is to create a uniform test for every file converter. This test is the creation of 1,000-unit cubes, from volume 0 (0 × 0 × 0) to 1-meter cubed (1,000 × 1,000 × 1,000), each incrementing by 1 millimeter. This tests the functionality of each converter and allows for comparison. This project was approached by first designing a program that would create 1,000 cubes of sizes incrementing by 1. The program was run in both of the BRL–CAD geometry editors before the files were changed to fit into the parameters of the other formats, allowing for the conversion of all different file types.

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converter, BRL–CAD, file, cube

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Student Biography

Steven J Nichols is a senior at the Science and Mathematics Academy at the Aberdeen High School in Maryland. He hopes to attend college and earn a computer-engineering degree. This is his first research experience.

1. Introduction/Background

Ballistics Research Laboratory–Computer-Aided Design (BRL–CAD) is a solid-modeling software system that was developed in the early 1980s as a way to model US Army vehicles. It uses an advanced ray-tracer to render models. Previously, it only rendered with Constructive Solid Geometry, in which Boolean operations are applied to simple primitives such as being added and subtracted from each other as well as using their intersection to create a nearly infinite number of shapes. Another feature of BRL–CAD is its set of geometry converters. Currently, it has the largest converter library in open-source software and is constantly expanding. Some converters have not been tested in decades, if at all.

2. Experiment/Calculations

Before the actual experiment, about 2 weeks were spent digitizing historical tapes and learning the C language. During this time, tapes from as early as the 1970s were recorded and saved on a computer for their historical value. These tapes included tech demos of new features being added to BRL–CAD, promotional videos for BRL–CAD (Fig. 1 shows its historic logo), and even details of the historic Cray supercomputer.

Fig. 1 Old historic BRL–CAD logo (left) and current logo (right)

My main project was to support testing all BRL–CAD file converters using a set of unit cubes. This was a set of 1,000 cubes ranging in dimensions from 1 mm × 1 mm × 1 mm to 1,000 mm × 1,000 mm × 1,000 mm. When rendered, these 1,000 cubes would appear as a single cube (as shown in Fig. 2).

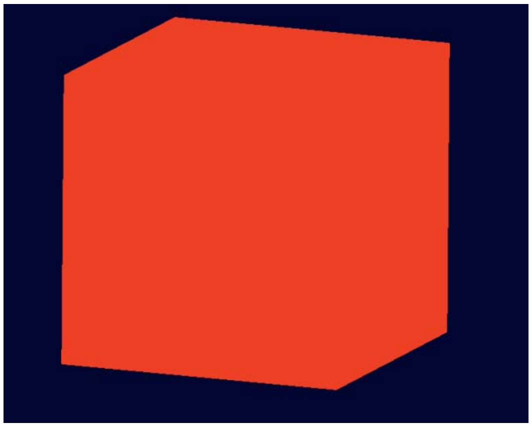

Fig. 2 Converter test cube set

The converters were split into 3 groups: those with both importers and exporters, those with importers only, and those with exporters only. Those with both importers and exporters were the easiest as the only thing that was needed was to convert the file using the built-in converter in command line. The file was converted to the new format using command line and then converted back using a different built-in converter. One notable example was the STereoLithography (STL) format converter. This converts the entire geometry into a triangular mesh (as shown in Fig. 3) and otherwise remains the same in terms of volume and area. However, most of the converters keep the model in cubes (as displayed in Fig. 4).

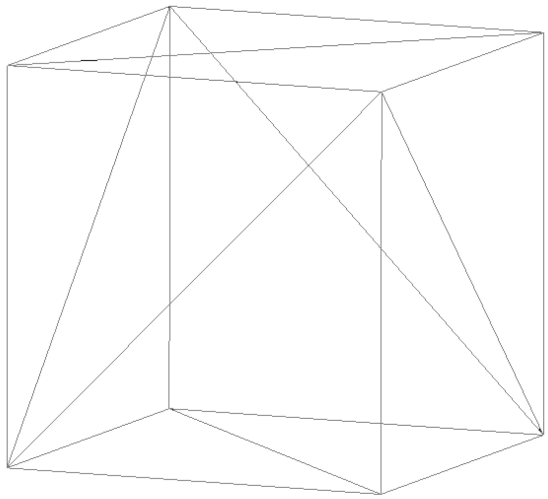

Fig. 3 Single cube in STL

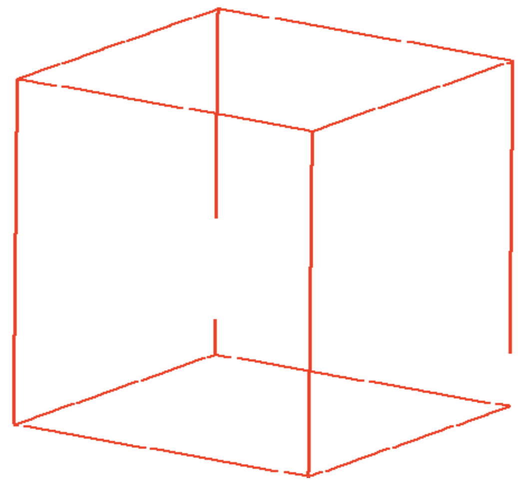

Fig. 4 Single cube in *.g*

For the importers only, the issue was “tricking” BRL–CAD into accepting the file as the file type that it required to convert back into a *.g* file. One example would be the FASTGEN format. This file type is able to raytrace completely flat (Plate Mode) geometry. Although it was not a problem faced during the project, it is something that needs to be considered in the future.

For the exporters only, the main challenge was to find a way to convert the file back into a *.g* file without messing it up on the user end. This was less difficult than the importers because it was much more uniform in the way that the file needed to be. There were no file types that were in continual use that were exporters only. The only example was the ACAD format that was used by Lockheed Martin.

3. Results and Discussion

From the converters tested, there were none that seemed to be incorrect from the tests. The tests involved 2 steps. The first was finding the volume of the bounding box of the entire shape. The bounding box is the smallest rectangular prism that can contain the entirety of the geometry. Because of the nature of the test (being made entirely out of cubes) the bounding box would also be the volume of the largest cube. A successful test would result in a volume of 1 m^3 or 1,000,000,000 mm^3. The second part would be to test each face of the cube using the *rtarea* command, which finds the exposed surface area of all of the exposed objects. Any deviation of size in the bounding box would indicate that the size of the cubes was not preserved and instead was warped in some way, or the cubes' dimensions were not that of the original.

4. Summary and Conclusions

Converters in BRL–CAD allow for easy importation and exportation of files from various types. This is useful because of the necessity to bring in files to BRL–CAD as well as the demand for it as a fast and easy tool. This allows BRL–CAD to act as a hub for conversion and, in turn, increases the number of users of BRL–CAD. The converters all work well, considering the age of some of them and the fact that changes in their target formats are not under the control of BRL–CAD. However, this might be countered by the fact that BRL–CAD has also been maintained and has one of the longest histories of traceable software changes of any open-source project.

List of Symbols, Abbreviations, and Acronyms

ACAD	AutoComputer-Aided Design
BRL–CAD	Ballistic Research Laboratory–Computer-Aided Design
FASTGEN	Fast Shotline Generator
GDiff	Geometry Differences
GUI	graphical user interface
STL	STereoLithography

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