

# RTVT

## Ray Tracing Visualization Tool

User's Guide

Brock Crews

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## Getting Started

## About RTVT

The Ray Tracing Visualization Tool was designed to aid those involved in ray tracing by providing a program that accepts the output of a ray tracing algorithm (see **Section 7** for output format) and renders the results to the screen per the user's choice of settings. RTVT gives the user flexibility in how the results are rendered by providing a Ray List Filter to select only those rays that meet a designated criterion. In addition to the Ray List Filter, the user has the ability to alter how the results are rendered to the screen, making RTVT a flexible instrument that many involved in ray tracing will find helpful.

RTVT is not only designed to be a visualization tool, but also assist in debugging ray tracing algorithms by providing features common to software debuggers. The user has the ability to animate the rays of interest in a variety of ways, and the animation can be controlled in order to easily relate the ray source file to what is being drawn to the screen.

## Installation

 To use RTVT, your computer must have a Microsoft Windows operating system.

### To Install RTVT

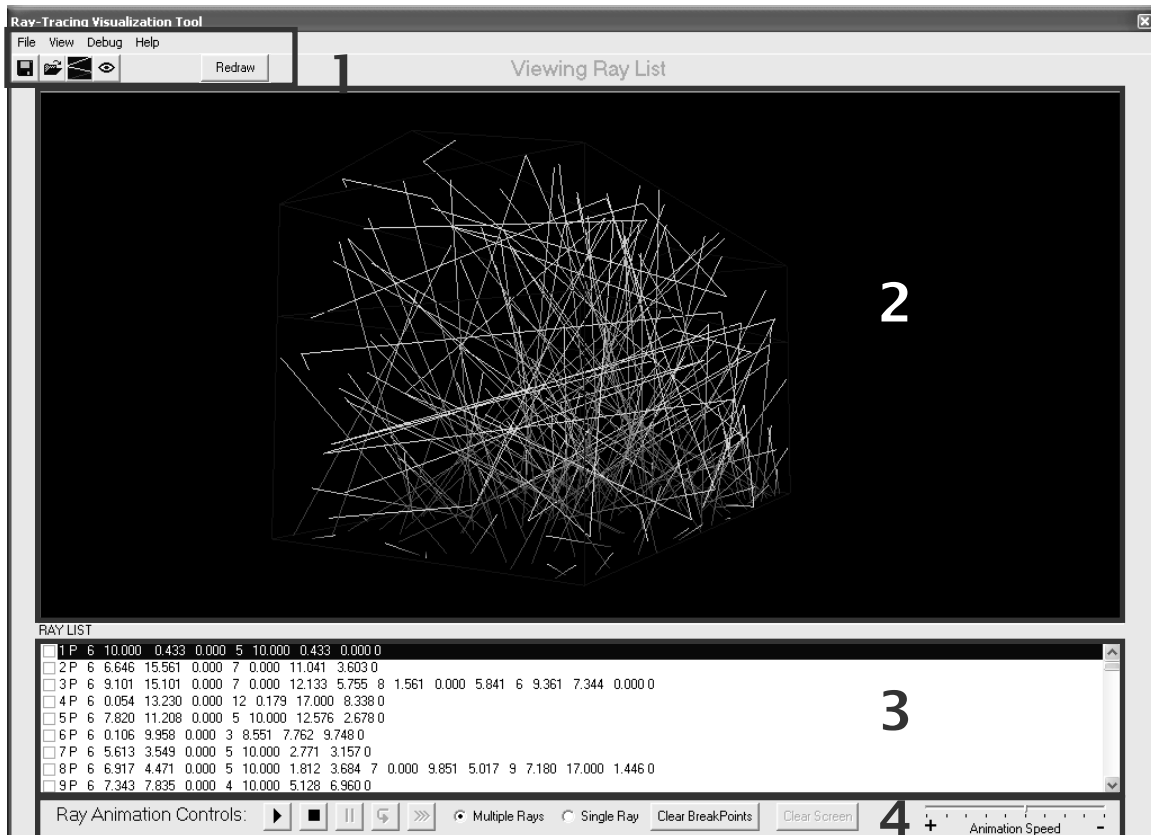
1. Insert the RTVT Installation CD in to the CD-ROM drive.
2. Select **Setup** from the CD and the installation will begin.



## RTVT Basics

## The User Interface

The user interface consists primarily of four areas: the top menu/command button row, the visualization screen, the ray list, and the animation controls toolbar.



1 The menu / command button row

2 The visualization screen

3 The Ray List

4 The animation controls toolbar



## Program Features

Each of the main areas of the user interface has its own feature. They are discussed by area.

### The Top Menu / Command Button Row

#### Save User Settings



You, as the user of RTVT, have the option of saving the user settings to minimize setup the next time that particular ray source file is opened. The extension for the user settings files are .rdb (Ray Debugger) and the file format can be seen in **Section 7**. The **File** menu can also both be used to access the Save dialog. The following information is saved in the .rdb file:

- The source file location
- The date saved
- The total number of rays in the source file
- The total number of points in the source file
- The number of ray segments in the longest ray
- The viewing options
- The Ray List Filter settings
- The center of the structure
- The breakpoint locations

#### Open a File



RTVT opens both .dat ray source files and .rdb ray debugger files. The formats for both file types can be seen in **Section 7**. When a .dat file is selected, RTVT scans the file and displays the number of rays and points, and all of RTVT's settings are at their default. Opening a .rdb file allows RTVT to forgo the scanning of the source file, and all of the user settings are retained from the last save. Upon opening a .rdb file, the ray list is loaded and the visualization screen is rendered per those settings. Breakpoints that were in place during the last save are also restored, allowing you to work where you left off. The file open dialog can be accessed via the menu as well.

#### Open the Ray List Filter Dialog



The Ray List Filter dialog contains options that can be set so that only the rays of interest are loaded into the Ray List. The dialog can also be opened via the menu system.



## Open the View Options Dialog

The View Options dialog holds the options for how the structure and rays are rendered in the visualization screen. As with the Ray List Filter, it can be opened via the menu system.

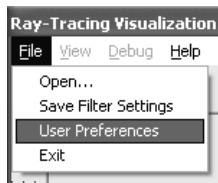


## Redraw the Picture

The **Redraw** button refreshes the image if the screen needs updating.

## Open the User Settings Dialog

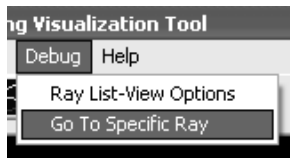
The User Settings Dialog contains the settings that are applied to any file opened with RTVT. The sensitivity of the mouse, the maximum number of rays to load into the Ray List, and the location of the viewing eye are all settings contained within. The dialog can be accessed using the **File** menu as seen below.



**File ⇒ User Preferences**

## Go to a Specific Ray

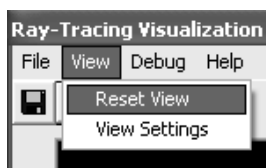
To speed up the search for a specific ray in the Ray List, this dialog can be accessed in the **Debug** menu. If the ray entered in the dialog box is present in the ray list, the Ray List will automatically scroll to the ray of interest and highlight it.



**Debug ⇒ Go To Specific Ray**

## Reset the View

There is the ability to reset the view in the visualization screen back to its default position. This can be done by using the menu system.



**View ⇒ Reset View**

## The Visualization Screen

The largest part of the user interface is the Visualization Screen, the area where the rays and structure are rendered per the user's settings. The rendered scene can be altered via the mouse or by the keyboard.

### Mouse Controls



The mouse can be used to rotate the scene in the visualization screen as well as zoom in and out. With the **left mouse button** down, the scene can be rotated about its center similar to what is seen in a CAD program. The **middle mouse button** can be used to zoom in and out, allowing more or less detail to be seen.

### Keyboard Controls



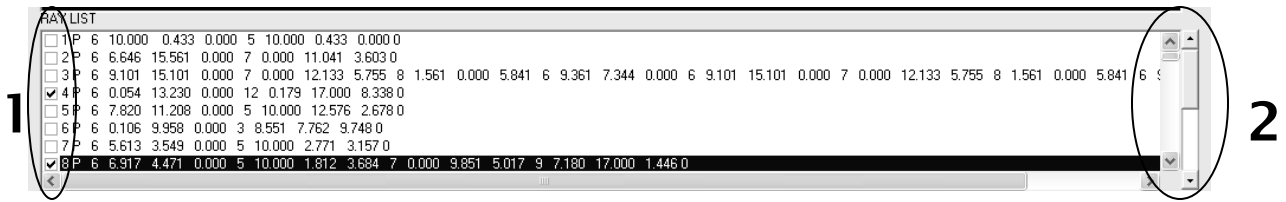
The keyboard can be used to execute all visualization screen alterations that the mouse can, plus more. The rotation of the scene can be done via the **W, X, A, and D keys**, while the **Shift Key** zooms in and the **Ctrl Key** zooms out. A feature exclusive to the keyboard is the ability to pan across the scene; done using the **Arrow Keys**.

Summary of Visualization Screen Controls

X Rotation	Z Rotation	Zoom In	Zoom Out	Pan
W, X Keys	A, D Keys	Shift Key	Ctrl Key	Arrow Keys
Left Mouse Button	Left Mouse Button	Middle Mouse Button	Middle Mouse Button	N/A

## The Ray List

In order to view or animate a ray, it must be present in the Ray List. The Ray List is loaded via the Ray List Filter and displays each loaded ray on a single line in the format of the ray source file with only one addition; the ray number is added to the beginning of each line. The mouse can be used to select a ray by clicking on it in the list. The mouse can also be used to place checks in the boxes at the beginning of each line. These checkboxes act as breakpoints during animation procedures. If needed, the ray list will have two vertical scroll bars located on the right-hand side. The left scroll bar moves the current list up and down, while the right scroll bar changes the "batch". The "batches" keep the rays in the order they appear in the ray source file and allow for scrolling through the rays in 1000 ray increments.



1 Breakpoints

2 Vertical Scroll Bars

## Animation Controls

The controls for the animation of the ray are located at the bottom of the user interface. The controls consist of command buttons for the main controls, a pair of options buttons to choose between multiple and single ray animation, and a slider to choose the speed at which the animation occurs.

### Play Button



This button begins the animation from the beginning of the ray list regardless of the previous animation actions taken.

### Stop Button



This button stops the animation and cancels any previous animation that has occurred to that point, displaying all rays in the Ray List. The **Stop Button** can be used to interrupt animation occurring or to simply leave the animation mode from a breakpoint.

### Pause Button



This button allows you to pause animation as it is occurring. When the button is pressed, the animation stops at the next ray in the list. Unlike the **Stop Button**, Pressing this button does not take RTVT out of the animation mode.

### Single Step Button



This button becomes active once a breakpoint is reached and each press of the button steps along the Ray List one ray at a time. The button becomes inactive again once the animation mode is left.

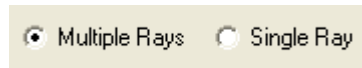
### Continue Button



This button becomes active once the animation has been paused or a breakpoint has been reached. Pressing this button resumes animation from the point at which it was pressed.

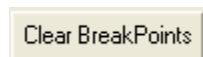
### Animation Option Buttons

The radio buttons in the animation control toolbar allows you to choose what type of animation you want to occur. **Multiple Rays** allows for the use of all of the animation controls while **Single Ray** only allows the animation of the selected ray.



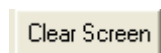
### Clear BreakPoints Button

This button can be used at any time to clear all breakpoints in the ray list.



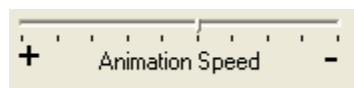
### Clear Screen Button

Clearing the screen is made possible by using this button. The screen can be cleared from any breakpoint or paused position.



### Animation Speed Slider Control

The slider has ten separate settings, each representing an animation speed. The + and - signs indicate which way to move the slider to adjust the speed to your liking.





## File Operations


## Opening a File

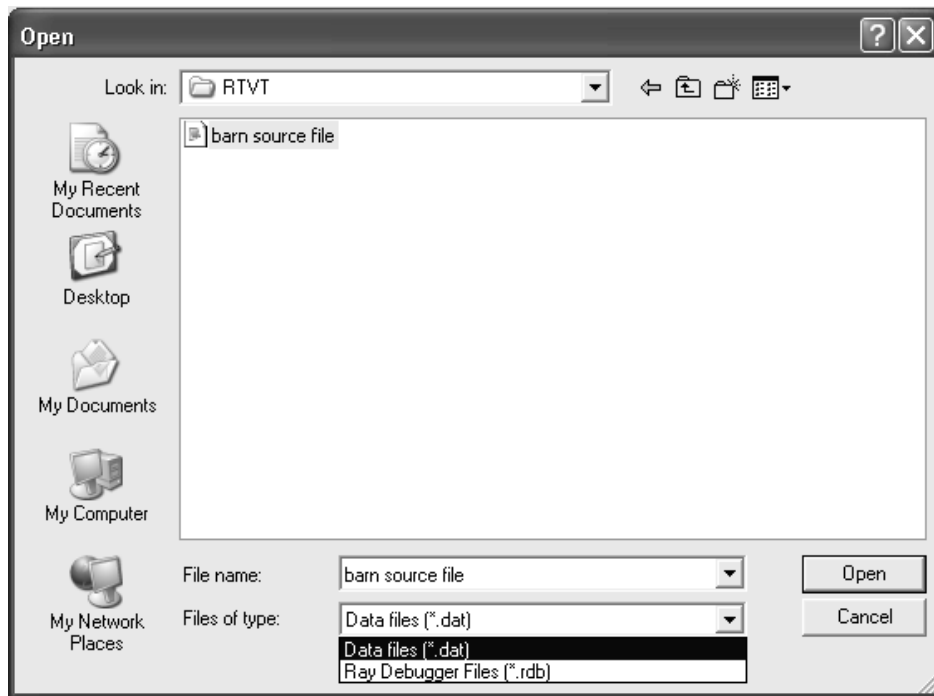
RTVT has the ability to open two different types of files:

- Data files (.dat) that are the outputs of ray tracing algorithms.
- Ray Debugger files (.rdb) that are the saved settings files of the RTVT program.

Note: Both file formats can be seen in **Section 7**.

### To open a new file of either type

1. Select **File** ⇒ **Open** from the menu or  from the top command button row.



2. Navigate via the “Open” dialog box to the desired source file. The “Files of type” drop-down menu must have the desired file type selected in order for it to be visible.

3. Select **Open** to begin scanning a .dat file or to begin reading in the desired rays of an .rdb file. See **Section 2** for an explanation of how the two file types are handled differently.

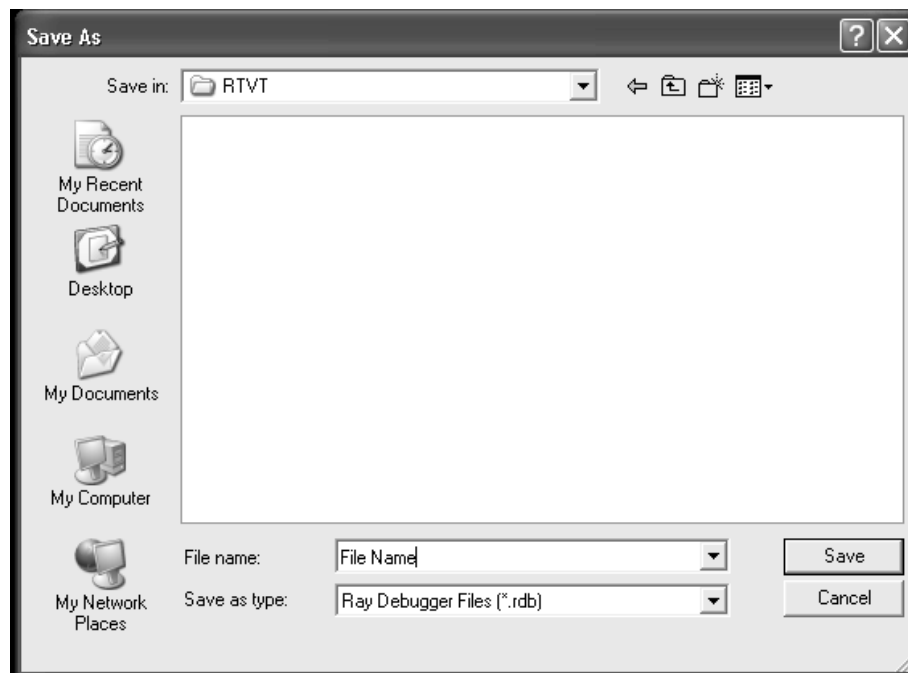
If a .dat file was opened, the Visualization Screen will only show the structure and the Ray List will be empty, waiting for filter criteria to be set in the Ray List Filter. If an .rdb file was selected, RTVT will begin loading the rays from the original source file per the saved settings in the Ray Debugger file. Once completed, all of the settings will be restored from the point at which they were saved.

## Saving User Settings

RTVT has the ability to save user settings so you do not have setup the program to your liking each time a particular source file is opened. See **Section 2** for a list of the settings that are preserved when a Ray Debugger file (.rdb) is created.

### To save the user settings by creating a Ray Debugger file

1. Select **File ⇒ Save User Settings** from the menu or click  on the top command button row.





2. Use the “Save As” dialog box to navigate to the location you want to save the Ray Debugger file and click **Save**. The setup of RTVT at that point will be saved to the .rdb file.

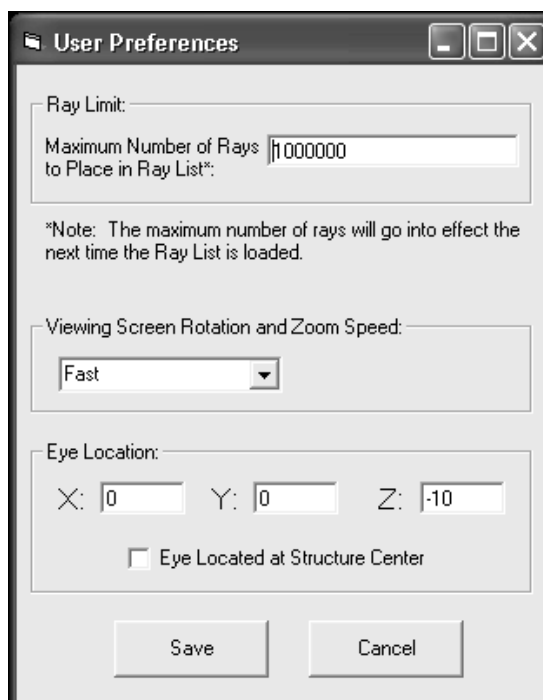
## Changing User Preferences

RTVT has preferences that can be changed that effect how every file is handled. These preferences are saved in a file named “User Preferences.ini” that is located in the RTVT root directory. The preferences saved in the file are:

- The maximum number of rays to read into the computer’s memory
- The sensitivity of the mouse when using it to alter the rendered scene.
- The location of the viewing eye.

### To change the user preferences

1. Select **File** ⇒ **User Preferences** from the menu. The User Preferences dialog box will appear.




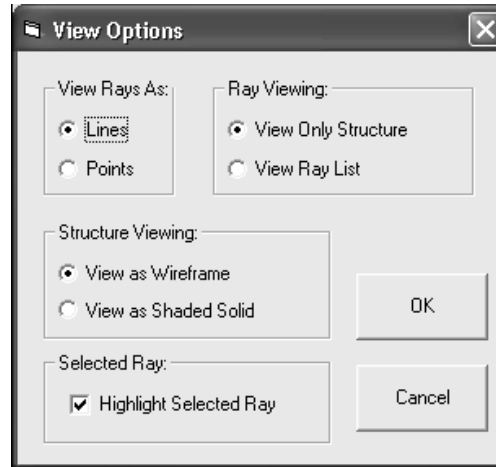
2. Alter any of the preferences and click **Save**. The maximum number of rays will go into effect the next time the Ray List is loaded.



## Viewing Options

## View Options Dialog Box

The view options dialog box can be accessed by either selecting **View ⇒ View Settings** or by clicking on  in the top command button row.



## Structure Viewing Options

There are two sets of options for how to view the structure in the Visualization Screen.

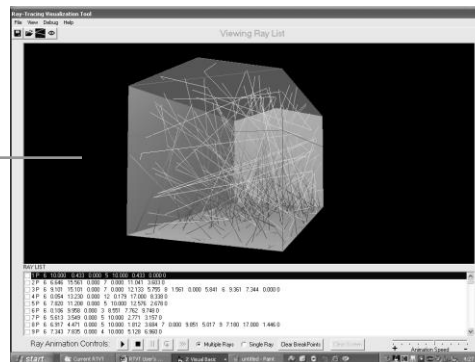
### Ray Viewing

This option allows for only the structure to be viewed. This is important when a multitude of rays are to be rendered and adjustments to the scene (rotation, zoom) need to be made. **View Only Structure** allows you to move the scene without forcing the program to render the rays as it is moving.

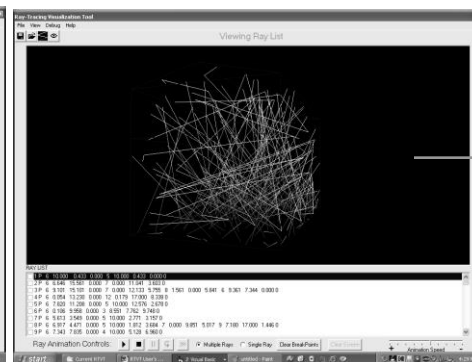
### Structure Viewing

This option lets you choose whether or not you want the structure rendered as a wireframe or as a solid. When the solid option is selected, the structure is rendered in a way so that you can also see into the structure.

View as  
shaded solid



View as  
wireframe



## Ray Viewing Options

As with the structure, there are also options for how the rays are rendered.

### **View Rays As**

This option allows you to see the rays represented by lines or points. If **Points** is selected, then the rays are represented only by dots where a ray originates, where it reflects off of surface, and where it is finally absorbed. This option also effects how the rays are seen when animated.


### **Selected Ray**

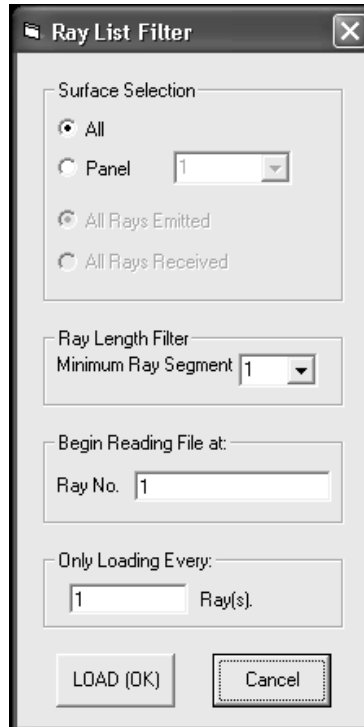
This option determines whether or not the selected ray in the Ray List is highlighted in the Visualization Screen. This option is in effect whether the rays are rendered as **Lines** or **Points**.



## The Ray List Filter

## The Ray List Filter Dialog Box

The Ray List Filter can be accessed by either selecting **Debug ⇒ Ray List Filter** or by click on  in the top command button row.



### Filter by Surface Interactions

The Ray List Filter's first setting deals with what surfaces each ray is emitted or completely absorbed by.

#### Surface Selection

You can limit what rays are allowed into the Ray List by selecting a panel of interest and then by selecting whether or not a ray must be emitted or received (completely absorbed) by that panel.

### Filter by Minimum Ray Length

The second criterion by which the Ray List can be filter by is the total number of segments in each ray.

#### Ray Length Filter

You can limit what rays are allowed into the Ray List by placing a limit on the minimum number of segments in a ray. For example, if a minimum of 2 segments is selected, then the rays must reflect at least once in order to be loaded into the Ray List.

## Other Ways to Limit the Number of Rays

The Ray List Filter has a couple of other ways that you can limit the number of rays allowed in the Ray List.

### **Begin Reading File at:**

You, as the user, can select the first ray RTVT begins reading into memory. This allows the program to skip over rays towards the beginning if they are of no importance.

### **Only Loading Every:**

It may be important to get a good overall feel for the behavior of a large source file, but not require that every single ray be read into memory. In this case, this option can be taken advantage of; by selecting an interval at which the rays are read.



## Ray Animation








## Using the Animation Controls

The purpose of each of the animation controls can be seen in **Section 2**. The following are discussions of how these controls can be used to animate multiple or single rays.

### Multiple Ray Animation

Each of the animation controls can be utilized when the **Multiple Rays** option is selected. The following is an example where each of the controls is used.

1. Once the Ray List has been loaded, check to see that **Multiple Rays** is selected. The options will allow RTVT to move from line to line in the Ray List, animating each ray as it is reached.
2. The **Animation Speed Slider Control** can be adjusted. Slower speeds allow you to see the animation of each ray in more detail, but may take much longer than desired. Choose a speed that fits your situation.
3. Select whether you want the rays to be viewed as **Rays** or **Points** in the View Options Dialog Box.
4. Select a line where you want the animation to stop when reached. Set a breakpoint at that line by placing a check in the box at the beginning of the line. The line which contains a breakpoint will not be executed when reached. The animation must be continued in order for that ray to be animated.
5. Click the Play Button  to begin the animation. The animation will continue until the breakpoint is reached.
6. Set another breakpoint, making sure it is set many lines away from the current location, then click **Continue** . The animation continues from the last breakpoint.
7. Click **Pause**  to stop the animation, but not exit the animation mode. Notice the animation stopped before a breakpoint was reached.
8. Click **Clear Screen** and notice how all of the rays drawn up to that point are now gone.

9. Click **Single Step**  several times and watch the rays be animated one by one.
10. Click **Stop**  to leave the animation mode and click **Clear All BreakPoints** to cancel out all of those set.

### Single Ray Animation

The animation of single rays only requires the use of the **Play** and **Stop** buttons. They play the same role as in multiple ray animation. The animation speed can be adjusted, but does not play a large role in single ray animation.



## File Formats

# Ray Source Code Format (.dat file)

```
v 1 0. 0.0 0.0
v 2 0. 0.0 6.2
v 3 0.0 0.0 9.4
v 4 5.0 0.0 10.6
v 5 10.0 0.0 9.4
v 6 10. 0.0 6.2
v 7 10. 0.0 0.0
v 8 0. 17.0 0.0
v 9 0. 17.0 6.2
v 10 0.0 17.0 9.4
v 11 5. 17.0 10.6
v 12 10.0 17.0 9.4
v 13 10. 17.0 6.2
v 14 10. 17.0 0.0
```

## Vertices Locations

V [space] Vertex Number [space] x-coordinate [space] y-coordinate [space] z-coordinate

I

## Separator

```
s 1 2 9 10 3
s 2 3 10 11 4
s 3 12 5 4 11
s 4 13 6 5 12
s 5 14 7 6 13
s 6 7 14 8 1
s 7 1 8 9 2
s 8 7 1 2 6
s 9 8 14 13 9
s 10 6 2 3 5
s 11 5 3 4 5
s 12 9 13 12 10
s 13 10 12 11 10
```

## Surface Information

s [space] Surface Number [space] vertex # [space] vertex # ...

Note: The surface vertices must be listed in a counter-clockwise manner, for proper rendering.

```
P 6 10.000 0.433 0.000 5 10.000 0.433 0.000 0
P 6 6.646 15.561 0.000 7 0.000 11.041 3.603 0
P 6 9.101 15.101 0.000 7 0.000 12.133 5.755 8 1.561 0.000 5.841 6 9.361 7.344 0.000 0
P 6 0.054 13.230 0.000 12 0.179 17.000 8.338 0
P 6 7.820 11.208 0.000 5 10.000 12.576 2.678 0
P 6 0.106 9.958 0.000 3 8.551 7.762 9.748 0
P 6 5.613 3.549 0.000 5 10.000 2.771 3.157 0
P 6 6.917 4.471 0.000 5 10.000 1.812 3.684 7 0.000 9.851 5.017 9 7.180 17.000 1.446 0
P 6 7.343 7.835 0.000 4 10.000 5.128 6.960 0
```

## Ray Information

[space] P [space] Surface Number [space] x-coordinate [space] y-coordinate [space] z-coordinate  
[space] Surface Number [space] x-coordinate [space] y-coordinate [space] z-coordinate [space]...  
[space] 0

## User Settings File Format (.rdb file)

C:\LocationOfSourceFile	← Source File Location
# 5/3/2005 #	← Date Saved
158	← Total Number of Rays in Source File
358	← Total Number of Points in Source File
6	← Maximum no. of Points in a Ray
255	← Boolean Indicating Rays Drawn as <b>Lines</b> or not
255	← Boolean Indicating if <b>All Panels</b> is checked in Filter
1	← If <b>Panel</b> is selected then this gives the Selected Panel
255	← Boolean for Emitted/Received Option in Filter
1	← Minimum Segment in Ray List Filter
1	← Start Ray in Ray List Filter
5	← x-coordinate of structure center
8.5	← y-coordinate of structure center
5.3	← z-coordinate of structure center
1	← Interval from Ray List Filter
0	← Boolean for whether or not Rays are drawn
255	← Boolean for whether or not the selected ray is highlighted
255	← Boolean for whether or not the structure is drawn as solid
0	← Locations of breakpoints...
4	
5	
6	