NAME

rad - render a RADIANCE scene

SYNOPSIS

rad [−s][-n | -N npr][−t][−e][−V][−w][−v view][−o device] rfile [VAR=value ..]

DESCRIPTION

Rad is an executive program that reads the given *rfile* and makes appropriate calls to *oconv(1), mkillum(1), rpict(1), pfilt(1),* and/or *rvu(1)* to render a specific scene. Variables in *rfile* give input files and qualitative information about the rendering(s) desired that together enable *rad* to intelligently set parameter values and control the simulation.

Normally, commands are echoed to the standard output as they are executed. The *−s* option tells *rad* to do its work silently. The *−n* option tells *rad* not to take any action (ie. not to actually execute any commands). The *−N* option instructs *rad* to run as many as *npr* rendering processes in parallel. The *−t* option tells *rad* to bring rendering files up to date relative to the input (scene description) files, without performing any actual calculations. If no octree exists, it is still necessary to run *oconv(1)* to create one, since the *−t* option will not create invalid (i.e. empty) files, and a valid octree is necessary for the correct operation of *rad*. The *−e* option tells *rad* to explicate all variables used for the simulation, including default values not specified in the input file, and print them on the standard output.

Normally, *rad* will produce one picture for each view given in *rfile*. The *−v* option may be used to specify a single desired view. The *view* argument may either be a complete view specification (enclosed in quotes and beginning with an optional identifier) or a number or single-word identifier to match a view defined in *rfile*. If the argument is one of the standard view identifiers, it may or may not be further elaborated in *rfile*. (See "view" variable description, below.) If the argument does not match any views in *rfile* and is not one of the standard views, no rendering will take place. This may be convenient when the only action desired of *rad* is the rebuilding of the octree. In particular, the argument "0" will never match a view.

If the *−V* option is given, each view will be printed on the standard output before being applied, in a form suitable for use in a view file or *rpict* rendering sequence. This is helpful as feedback or for accessing the *rad* view assignments without necessarily starting a rendering.

By default, *rad* will run *rpict* and *pfilt* to produce a picture for each view. The *−o* option specifies an output device for *rvu* (usually "x11") and runs this interactive program instead, using the first view in *rfile* or the view given with the *−v* option as the starting point.

Additional variable settings may be added or overridden on the command line following *rfile*. Upper case variables specified more than once will result in a warning message (unless the *−w* option is present), and the last value given will be the one used.

The *−w* option turns off warnings about multiply and misassigned variables.

Rendering variable assignments appear one per line in *rfile*. The name of the variable is followed by an equals sign ('=') and its value(s). The end of line may be escaped with a backslash ('\'), though it is not usually necessary since additional variable values may be given in multiple assignments. Variables that should have only one value are given in upper case. Variables that may have multiple values are given in lower case. Variables may be abbreviated by their first three letters. Comments in *rfile* start with a pound sign ('#') and proceed to the end of line.

The rendering variables, their interpretations and default values are given below.

OCTREE The name of the octree file. The default name is the same as *rfile* but with any suffix replaced by ".oct". (The octree must be a file -- *rad* cannot work with commands that produce octrees.)

ZONE This variable specifies the volume of interest for this simulation. The first word is either "Interior" or "Exterior", depending on whether the zone is to be observed from the inside or the outside, respectively. (A single letter may be given, and case does not matter.) The following six numbers are the minimum and maximum X coordinates, minimum and maximum Y, and minimum and maximum Z for the zone perimeter. It is important to give the zone as it is used to determine many of the rendering parameters. The default exterior zone is the bounding cube for the scene as computed by *oconv.*

EXPOSURE
This variable tells *rad* how to adjust the exposure for display. It is important to set this variable properly as it is used to determine the ambient value. An appropriate setting may be discovered by running *rvu* and noting the exposure given by the "exposure =" command. As in *rvu* and *pfilt,* the exposure setting may be given either as a multiplier or as a number of f−stop adjustments (eg. +2 or −1.5). There is no default value for this variable. If it is not given, an average level will be computed by *pfilt* and the ambient value will be set to 10 for exterior zones and 0.01 for interior zones.

EYESEP The interocular spacing for stereo viewing. I.e., the world distance between the pupils of the left and right eyes. The default value is the sum of the three "ZONE" dimensions divided by 100.

scene This variable is used to specify one or more scene input files. These files will be given together with the materials file(s) and any options specified by the "oconv" variable to *oconv* to produce the octree given by the "OCTREE" variable. In-line commands may be specified in quotes instead of a file, beginning with an exclamation mark ('!'). If the "scene" variable is not present, then the octree must already exist in order for *rad* to work. Even if this variable is given, *oconv* will not be run unless the octree is out of date with respect to the input files. Note that the order of files in this variable is important for *oconv* to work properly, and files given in later variable assignments will appear after previous ones on the *oconv* command line.

materials This variable is used to specify files that, although they must appear on the *oconv* command line, do not affect the actual octree itself. Keeping the materials in separate files allows them to be modified without requiring the octree to be rebuilt (a sometimes costly procedure). These files should not contain any geometry, and the *−f* option must not be given in the "oconv" variable for this to work.

illum This variable is used to specify files with surfaces to be converted into illum sources by *mkillum(1).* When this variable is given, additional octree files will be created to contain the scene before and after illum source conversion. These files will be named according to the (default) value of the *OCTREEE* variable, with either a '0' or a '1' appearing just before the file type suffix (usually ".oct").

objects This variable is used for files that, although they do not appear on the *oconv* command line, contain geometric information that is referenced indirectly by the scene files. If any of these files is changed, the octree will be rebuilt. (The *raddepend(1)* command may be used to find these dependencies automatically.)

view This variable is used to specify a desired view for this zone. Any number of "view" lines may be given, and each will result in a rendered picture (unless the *−v* or *−o* option is specified). The value for this variable is an optional identifier followed by any number of view options (see *rpict(1)* for a complete listing). The identifier is used in file naming and associating a desired view with the *−v* command line option. Also, there are several standard view identifiers defined by *rad.* These standard views are specified by strings of the form "[Xx]?[Yy]?[Zz]?[vlcahs]?". (That is, an optional upper or lower case X followed by an optional upper or lower case Y followed by an optional upper or lower case Z followed by an optional lower case V, L, C, A or H.) The letters indicate the desired view position, where upper case X means maximum X, lower case means minimum and so on. The final letter is the view type, where 'v' is perspective (the default), 'l' is parallel, 'c' is a cylindrical panorama, is a planisphere (stereographic) fisheye. A perspective view from maximum X, minimum Y would be "Xy" or "Xyv". A parallel view from maximum Z would be "Zl". If "ZONE" is an interior zone, the standard views will be inside the perimeter. If it is an exterior zone, the standard views will be outside. Note that the standard views are best used as starting points, and additional arguments may be given after the identifier to modify a standard view to suit a particular model. The default view is "X" if no views are specified. A single specified view of "0" means no views will be automatically generated.

UP The vertical axis for this scene. A negative axis may be specified with a minus sign (eg. "−Y"). There is no default value for this variable, although the standard views assume Z is up if no other axis is specified.

RESOLUTION
This variable specifies the desired final picture resolution. If only a single number is given, this value will be used for both the horizontal and vertical picture dimensions. If two numbers are given, the first is the horizontal resolution and the second is the vertical resolution. If three numbers are given, the third is taken as the pixel aspect ratio for the final picture (a real value). If the pixel aspect ratio is zero, the exact dimensions given will be those produced. Otherwise, they will be used as a frame in which the final image must fit. The default value for this variable is 512.

QUALITY
This variable sets the overall rendering quality desired. It can have one of three values, "LOW", "MEDIUM" or "HIGH". These may be abbreviated by their first letter, and may be in upper or lower case. Most of the rendering options will be affected by this setting. The default value is "L".

PENUMBRAS
This is a boolean variable indicating whether or not penumbras are desired. A value of "TRUE" will result in penumbras (soft shadows), and a value of "FALSE" will result in no penumbras (sharp shadows). True and false may be written in upper or lower case, and may be abbreviated by a single letter. Renderings generally proceed much faster without penumbras. The default value is "F".

INDIRECT
This variable indicates how many diffuse reflections are important in the general lighting of this zone. A direct lighting system (eg. fluorescent troffers recessed in the ceiling) corresponds to an indirect level of 0. An indirect lighting system (eg. hanging fluorescents directed at a reflective ceiling) corresponds to an indirect level of 1. A diffuse light shelf reflecting sunlight onto the ceiling would correspond to an indirect level of 2. The setting of this variable partially determines how many interreflections will be calculated. The default value is 0.

PICTURE This is the root name of the output picture file(s). This name will have appended the view identifier (or a number if no id was used) and a ".hdr" suffix. If a picture corresponding to a specific view exists and is not out of date with respect to the given octree, it will not be re-rendered. The default value for this variable is the root portion of *rfile.*

RAWFILE
This is the root name of the finished, raw *rpict* output file. If specified, *rad* will rename the original *rpict* output file once it is finished and filtered rather than removing it, which is the default action. The given root name will be expanded in the same way as the "PICTURE" variable, and if the "RAWFILE" and "PICTURE" variables are identical, then no filtering will take place.

ZFILE This is the root name of the raw distance file produced by the *−z* option of *rpict.* To this root name, an underscore plus the view name plus a ".zbf" suffix will be added. If no "ZFILE" is specified, none will be produced.

AMBFILE
This is the name of the file where "ambient" or diffuse interreflection values will be stored by *rpict* or *rvu.* Although it is not required, an ambient file should be given whenever an interreflection calculation is expected. This will optimize successive runs and minimize artifacts. An interreflection calculation will take place when the "QUALITY" variable is set to HIGH, or when the "QUALITY" variable is set to MEDIUM and "INDIRECT" is positive. There is no default value for this variable.

DETAIL This variable specifies the level of visual detail in this zone, and is used to determine image sampling rate, among other things. If there are few surfaces and simple shading, then this should be set to LOW. For a zone with some furniture it might be set to MEDIUM. If the space is very cluttered or contains a lot of geometric detail and textures, then it should be set to HIGH. The default value is "M".

VARIABILITY
This variable tells *rad* how much light varies over the surfaces of this zone, and is used to determine what level of sampling is necessary in the indirect calculation. For an electric lighting system with uniform coverage, the value should be set to LOW. For a space with spot lighting or a window with sky illumination only, it might be set to MEDIUM. For a space with penetrating sunlight casting bright patches in a few places, it should be set to HIGH. The default value is "L".

PGMAP This variable designates a global photon map to be generated by *mkpmap(1)* and used to accelerate rendering. The file name must be followed by the number of photons to be stored in the map, and this number may be followed by a bandwidth for rendering. There is no default value, meaning that a global photon map will not normally be created.

PCMAP This variable designates a caustic photon map to be generated by *mkpmap(1)* and used during renderings to model light transmission by reflecting and refracting surfaces. The file name must be followed by the number of photons to be stored in the map, and this number may be followed by a bandwidth for rendering. There is no default value, meaning that a caustic photon map will not normally be created.

OPTFILE This is the name of a file in which *rad* will place the appropriate rendering options. This file can later be accessed by *rpict* or *rvu* in subsequent manual runs using the at-sign ('@') file insert option. (Using an "OPTFILE" also reduces the length of the rendering command, which improves appearance and may even be necessary on some systems.) There is no default value for this variable.

REPORT This variable may be used to specify a reporting interval for batch rendering. Given in minutes, this value is multiplied by 60 and passed to *rpict* with the −*t* option. If a filename is given after the interval, it will be used as the error file for reports and error messages instead of the standard error. (See the −*e* option of *rpict(1)*. There is no default value for this variable.

oconv This variable may be used to specify special options to *oconv.* If the first word of the first instance of this variable is not an option, it will be used in place of the default command path, "oconv". See the *oconv(1)* manual page for a list of valid options.

mkillum This variable may be used to specify additional options to *mkillum.* If the first word of the first instance of this variable is not an option, it will be used in place of the default command path, "mkillum". See the *rtrace(1)* manual page for a list of valid options.

mkpmap This variable may be used to specify additional options to *mkpmap.* If the first word of the first instance of this variable is not an option, it will be used in place of the default command path, "mkpmap". See the *mkpmap(1)* manual page for a list of valid options.

render This variable may be used to specify additional options to *rpict* or *rvu.* These options will appear after the options set automatically by *rad,* and thus will override the default values.

rpict This variable may be used to specify overriding options specific to *rpict.* If the first word of the first instance of this variable is not an option, it will be used in place of the default command path, "rpict". See the *rpict(1)* man page for a list of valid options.

rvu This variable may be used to specify overriding options specific to *rvu.* If the first word of the first instance of this variable is not an option, it will be used in place of the default command path, "rvu". See the *rvu(1)* man page for a list of valid options.

pfilt This variable may be used to specify additional options to *pfilt.* If the first word of the first instance of this variable is not an option, it will be used in place of the default command path, "pfilt". See the *pfilt(1)* manual page for details.

EXAMPLES

A minimal input file for *rad* might look like this:

```
::::::::::
sample.rif
::::::::::
# The octree we want to use:
OCTREE= tutor.oct                # w/o this line, name would be "sample.oct"
# Our scene input files:
scene= sky.rad outside.rad room.rad srcwindow.rad
# The interior zone cavity:
ZONE= I  0 3  0 2  0 1.75        # default would be scene bounding cube
# The z-axis is up:
UP= Z                            # no default - would use view spec.
# Our exposure needs one f-stop boost:
EXPOSURE= +1                     # default is computed ex post facto
```

Note that we have not specified any views in the file above. The standard default view "X" would be used if we were to run *rad* on this file. If we only want to see what default values *rad* would use without actually executing anything, we can invoke it thus:

```
rad −n −e sample.rif
```

This will print the variables we have given as well as default values *rad* has assigned for us. Also, we will see the list of commands that *rad* would have executed had the *−n* option not been present. (Note if the octree, "tutor.oct", is not present, an error will result as it is needed to determine some of the opiton settings.)

Different option combinations have specific uses, ie:

```
rad −v 0 sample.rif OPT=samp.opt # build octree, put options in "sample.opt"
rad −n −e −s sample.rif > full.rif     # make a complete rad file
rad −n sample.rif > script.sh          # make a script of commands
rad −V −v Zl −n −s sample.rif > plan.vf        # make a plan view file
rad −t sample.rif              # update files after minor change to input
rad −s sample.rif &                    # execute silently in the background
rad −N 2 sample.rif          # render views using two parallel rpict calls
rad −N 4 -v 1 sample.rif     # render first view with four rpiece calls
```

If we decide that the default values *rad* has chosen for our variables are not all appropriate, we can add some more assignments to the file:

```
QUAL= MED               # default was low
DET= low                # default was medium - our space is almost empty
PEN= True               # we want to see soft shadows from our window
VAR= hi         # daylight can result in fairly harsh lighting
view= XYa −vv 120       # let’s try a fisheye view
PICT= tutor             # our picture name will be "tutor_XYa.hdr"
```

Note the use of abbreviations, and the modification of a standard view. Now we can invoke *rad* to take a look at our scene interactively with *rvu:*

```
rad −o x11 sample.rif
```

Rad will run *oconv* first to create the octree (assuming it doesn’t already exist), then *rvu* with a long list of options. Let’s say that from within *rvu,* we wrote out the view files "view1.vp" and "view2.vp". We could add these to "sample.rif" like so:

```
view= vw1 −vf view1.vp          # Our first view
view= vw2 −vf view2.vp          # Our second view
RESOLUTION= 1024                # Let's go for a higher resolution result
```

To start *rvu* again using vw2 instead of the default, we use:

```
rad −o x11 −v vw2 sample.rif
```

Once we are happy with the variable settings in our file, we can run *rad* in the background to produce one image for each view:

```
rad sample.rif REP=5 >& errfile &
```

This will report progress every five minutes to "errfile".

FILES

$(PICTURE)_$(view).unf Unfinished output of *rpict*

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BUGS

You cannot run more than one *rad* process at a time on the same input file, as the second process will attempt to recover the output files of the first process, damaging the results. The exceptions to this are running interactively via the *−o* option, or rendering different views using the *−v* option.

Incremental building of octrees is not supported as it would add considerable complexity to *rad*. Complicated scene builds should still be left to *make(1),* which has a robust mechanism for handling hierarchical dependencies. If *make* is used in this fashion, then only the "OCTREE" variable of *rad* is needed.

The use of some *pfilt* options is awkward, since the "EXPOSURE" variable results in a single pass invocation (the *−1* option of *pfilt* and two passes are necessary for certain effects, such as star patterns. The way around this problem is to specify a "RAWFILE" that is the same as the "PICTURE" variable so that no filtering takes place, then call *pfilt* manually. This is preferable to leaving out the "EXPOSURE" variable, since the exposure level is needed to accurately determine the ambient value for *rpict*.

The use of upper and lower case naming for the standard views may be problematic on systems that don't distinguish case in filenames.

SEE ALSO

glrad(1), make(1), mkillum(1), mkpmap(1), objview(1), oconv(1), pfilt(1), raddepend(1), ranimate(1), rholo(1), rpict(1), rpiece(1), rtrace(1), rvu(1), touch(1), vgaimage(1), ximage(1)