The Radiance \textit{rtcontrib} Program

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Basic Idea

- Normally, details about what sources contributed to a pixel are thrown away.
- Saving this information allows different source contributions to be substituted.
- More generally, the flux transfer between a point and any other point may be quantified.
Quantifying Contributions

Q: How much came from each light bank?
Contribution Coefficients

• A “contribution coefficient” is the fraction of a ray’s return value that will ultimately apply

  • This is closely related, but not equal, to the “ray weight” reported by -otw

• ‘T’ option for rtrace -o traces to light sources

• The ‘W’ option reports contribution coefficient
A Simple Example

Eye

Diffuse=25%
Specular=3%

Src

\[ -\alpha_T W = 0.03 \times 0.40 \Omega_2 \]

\[ -\alpha_T W = 0.25 \Omega_1 \]

\[ -\alpha_T W = 0.03 \]

Diffuse=40%
Specular=0
Problem: Daughter Rays
Diffuse Interreflections
**rtcontrib: Gather Rays**

- Gather contributions & coefficients and sum them up logically

- Different applications require different sums:
  - Daylight coefficients sum at sky patches
  - Luminaire model may sum at lamp surface

- **rtcontrib** provides general mechanism, while **rtrace** handles actual ray-tracing
General Operation

• Looks like \texttt{rtrace} command, similar options

• Options tell \texttt{rtcontrib} where to collect values
  • required modifier name(s)
  • optional bin number based on ray direction and intersection point

• Output sent to one or more files or commands
  • specified by modifier name and bin number
Lighting Example

vwrays -ff -x 1024 -y 1024 -vf model.vp \ | rtcontrib -V+ -o part_%s.pic -m fluor1 -m fluor2 \ -ffc `vwrays -d -x 1024 -y 1024 -vf model.vp` -u+ model.oct
rtcontrib Options

General options:
- \( -n \ N \) start \( N \) \texttt{rtrace} processes
- \( -r \) recover previously aborted calculation
- \( -e \ expr \) compile definitions string
- \( -f \ source \) compile definitions file

Modifier options:
- \( -o \ ospec \) output specification
- \( -b \ binv \) bin number

Modifier specification:
- \( -m \ mod \) modifier name
- \( -M \ file \) modifier list from file

May contain ‘!’ and ‘%d’ or ‘%s’

Integer expression, or ‘0’ to disable
Lighting Example Dissection

vwrays -ff -x 1024 -y 1024 -vf model.vp \
| rtcontrib -o part_%s.pic -m fluor1 -m fluor2 \
-ffc `vwrays -d -x 1024 -y 1024 -vf model.vp` model.oct
vwrays provides primary ray origins and directions (in floating point) for pictures to be generated by rtcontrib.

vwrays -ff -x 1024 -y 1024 -vf model.vp \ 
| rtcontrib -o part_%s.pic -m fluor1 -m fluor2 \ 
-ffc `vwrays -d -x 1024 -y 1024 -vf model.vp` model.oct

Second invocation reports actual resolution (-x 1024 -y 690)
Lighting Example Dissection

Specifies output files and associated modifiers, creating `part_fluor1.pic` and `part_fluor2.pic`.

```
vwrays -ff -x 1024 -y 1024 -vf model.vp \ | rtcontrib -o part_%s.pic -m fluor1 -m fluor2 \ -ffc `vwrays -d -x 1024 -y 1024 -vf model.vp` model.oct
```

The `-ffc` option is an `rtrace` option telling `rtcontrib` to expect single-precision floats on input and produce RGBE colors on output.
Discrete solar positions at each patch location improve rendering of sharp shadow features. Actual sun position is interpolated from four closest suns.

From John Mardaljevic’s thesis

Daylight Coefficients
Daylight Coefficient Example

Blinds: up, top, down @ 10° increments
Optional overhang

Upper & lower glass: 42 separate runs of 146 sky patches & 145 solar patches
One hemispherical fisheye view
Example Contributions (1)

Sky patch 045 from lower glass
no overhang
no blinds

Sun patch 045 from lower glass
no overhang
no blinds
Example Contributions (2)

Sky patch 045 from lower glass with overhang blinds @ 20°

Sun patch 045 from lower glass with overhang blinds @ 20°
Dec 28
Overhang
10 am
blinds down
@ 10°
Example with Captured Sky

- Parthenon model created by Paul Debevec & Co. at USC’s ICT from 100’s of site laser scans
- Los Angeles sky captured by Jessi Stumpfel on the one cloudy day she could find
- `rtcontrib` run plus `pcomb` sums for 690 animation frames done in 6 hours on G5 Quad
Parthenon Rendering Method

• Run `rtcontrib` to compute each Tregenza sky patch DC contribution as a partial image

• Use low-resolution version of captured sky to compute Tregenza patch radiances

• Use radiance as coefficients in `pcomb` command to combine partial images
rtcontrib -x 2048 -y 1361 -ffc -ab 2 -ad 1024 -f
tregenza.cal -b tbin -o p%d.hdr -m white -n 4
parth.oct < rays.flt

Then, for each frame time:

mksky.csh $time | oconv - > capsky.oct

rtrace -h -w -dv- capsky.oct < tregsamp.dat |
total -64 -m > pval.dat

pcomb -h `rcalc -o '-s ${$1} p${recno-1}.hdr'
pval.dat` > f$time.hdr
Example pcomb Command

```bash
```
Using **dctimestep**

dctimestep p%d.hdr pval.dat > f10-38.hdr

*Much faster!*

This didn’t exist when the animation was done.
Computing Caustics (1)

Send rays from “sun”

Accumulate results on 5 submerged pool surfaces
Computing Caustics (2)

vwrays -pj .6 -vf pool_par.vf -x 500 -y 500 -ff \  
| rtcontrib -w -ffc -c 0 \  
   -f pool_coords.cal -o %s_caustics.pic \  
   -b floor_bin -bn 7500 -x 50 -y 150 -m floor \  
   -b s_wall_bin -bn 1500 -x 50 -y 30 -m s_wall \  
   -b n_wall_bin -bn 1500 -x 50 -y 30 -m n_wall \  
   -b e_wall_bin -bn 4500 -x 150 -y 30 -m e_wall \  
   -b w_wall_bin -bn 4500 -x 150 -y 30 -m w_wall \  
catchscene.oct

{ south wall bins }
SWallXres : 50;
SWallZres : 30;
SWallWidth : 5 {meters};
SWallOrigX : -2.5;
SWallHeight : 3 {meters};
SWallOrigZ : -3.08;
s_wall_bin = floor(SWallXres*(Px - SWallOrigX)/SWallWidth) + floor(SWallZres*(1 - (Pz - SWallOrigZ)/SWallHeight))*SWallXres;
void colorpict s_wall_pat
7 red green blue s_wall_caustics.pic . (Px--2.5)/3 (Pz--3.08)/3
0
0

s_wallPat glow s_wall
0
0
4 5 5 5 0

Computing Caustics (3)
The Care and Feeding of *rtcontrib*

- If you use `-b`, best to use `-bn` as well
- Careful where your place `-m` and `-M` options
- Tracking absolute flux values using `-c` requires careful distribution of incident rays
- Remember that contributions are triplet values
- Learn the difference between `-V-` and `-V+`
- Options must be appropriate to pure MC
What Is Pure Monte Carlo?

- No indirect cache (-aa 0)
- Uncorrelated sampling (-u+)
- Russian roulette termination (-lr ≤0)
- Other recommended settings:
  --as 0 -dt 0 -dj 0.9 -sj 1
  --lw setting very important: 1/#paths
No Ambient Cache?

- `rtcontrib` needs to know at any point what contribution will ultimately be made.
- Ambient values are stored and reused later in an untraceable way.
- `Daysim` avoids this issue by storing daylight coefficients in each ambient value.
- `rtcontrib` more general and memory-efficient.
Multiprocessing in \texttt{rtcontrib}

- Supported with \texttt{-n} option, but...
- Unless there are many interactions between each ray start and each monitored surface...
- \texttt{rtcontrib} process takes much of the time
- Non-linear speedup with multiple \texttt{rtrace}'s
- Net savings come from coefficient method
Number of Open Files

- Since many components are often desired, the number of open files may be a constraint

- Raise max. open descriptors/process:
  - `ulimit -n 1024`, or
  - `limit descriptors 1024`

- This may still be inadequate in some cases....
Recovery Options

- If output is to binary file(s) via \(-o\) option, &...
- Exact command is re-issued with \(-r\) option,
- Then \texttt{rtcontrib} attempts to append data
- So make sure old process is dead, first!
- If \texttt{-c 0} option is in effect, sums are updated
  - very useful for progressive calculations
General Sympathy

- `rtcontrib` is one of the most difficult commands to use in Radiance
- It is also one of the most powerful
- Think about learning `rpict` from scratch, again
- Along with `rtrace`...
- Then multiply by a factor of 2 or so
Please Ask

- Inquiries and suggestions are welcome
- There is much to be gained, but that first step...
- Axel Jacobs’ tutorial is an excellent start
- Don’t be shy about using the mailing list
Questions?