25 Years of Radiance at ARUP
1989-1996
The pioneers
Andy Sedgwick
Dear Greg Ward,

Radiance Software

Please find enclosed a copy of our Radiance Request Form, a 30 byte tape cartridge and a pre-paid mailer for our San Francisco office. We will be grateful to receive a copy of the Radiance software, as we have followed with interest the developments you have presented in last year’s ACI Proceedings, and in the IJIS Journal.

You may remember that one of our directors, Tom Barker, visited your laboratories about nine months ago. He was most impressed with the graphic images you demonstrated, and which could provide an exciting way of presenting architectural and engineering schemes.

We hope that we will provide useful feedback to you as we explore the software and make our own developments.

Yours sincerely,

Andrew Sedgwick

Ove Arup & Partners
5247/01/AS/29W
16 October 1969

Greg Ward
Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley
CA 94720
Steve Walker
Sun Sparc – circa 1991, 8MB RAM, 40MHz (?) Radiance version 1.2
Rendering and printing with Radiance circa 1992

• Weds 10:30pm: started final rendering run

• Thurs 10am: peeked at intermediate results, stopped rpict and fixed scene problems and restarted final rendering

• Friday 12noon: realised rendering would be 3 weeks late at current pace. Started working on optimisations and negotiated deadline extension to Saturday lunchtime.

• Saturday 2am: started final rendering run…
Rendering and printing with Radiance circa 1992

- Saturday 9am: converted output file and wrote to transfer media (1/4” tape), 250MB capacity

- Saturday 11am: boarded train to Hatfield – special favour from a friend with a slide film writer and NEXT computer
Rendering and printing with Radiance circa 1992

- Saturday 1pm: woke up in Peterborough (missed target by 30 miles). Paid penalty fare and set off on a southbound train to Hatfield.
- Saturday 4pm: slides written and travelling back to London.
- Saturday 8pm: special courier package sent, 36 hours without sleep…
Rendering and printing with Radiance circa 1992

• Monday 9am: client asked for more copies of slides…
Silicon Graphics Indigo 2 *Extreme* circa 1993
150MHz R4400 CPU, 96MB RAM
£30,000

Radiance version 2.1
Florence Lam
OSAKA DOME COMPETITION
LITHTING

Achieving ideal natural lighting conditions in sports stadia can be particularly difficult without resorting to using large areas of translucent materials. These are expensive, require maintenance and generally have poor acoustic absorbency properties. Another solution is to adopt a double skin which is also expensive and often slow to build.

The favoured lighting conditions in baseball and other sports stadia are:

- The intensity of illuminance in the hemisphere enclosed should be maximum overhead gently reducing to a minimal level at the perimeter seating.

- The contrast between light and darker surfaces at any point in the hemisphere should be minimised. This is necessary for good playing conditions where the players and spectators can easily follow a ball.

- Direct sunlight onto the playing areas or spectators should be kept to a minimum.

- The occurrence of shadows on the playing field should be avoided.

LIGHTING CONCEPT
Interior view towards the tier.
Overcast sky on 21 June at 14:00
Aerial view day-time scene
Overcast sky on 21 June at 14:00.
Aerial view night-time scene.
External ambient light
1996 - 2003

The golden age
Jeff Shaw
Jeff Shaw
Radiance in Arup
1996-2001

“C Shell, C Shell by J. C. Shaw…”
[sorry about that!]
The Rothko Chapel, Houston, USA – 1997-1998
The Rothko Chapel, Houston, Texas
Illuminance Distribution on Paintings from Electric Lighting
North Apse Triptych - Average = 224 lux ; Uniformity = 2.1:1
South Painting - Average = 232 lux ; Uniformity = 1.8:1
East & West Triptychs - Average = 244 lux ; Uniformity = 1.6:1
NE, NW, SE & SW Paintings - Average = 218 lux ; Uniformity = 1.7:1
Floor - Average = 145 lux ; Uniformity = 1.6:1
The Rothko Chapel, Houston, USA – 1997-1998
#!/bin/csh -f
#
# shell script to generate shadow movement movie from fixed viewpoint
#
# RADIANCE PICTURES, TIFF FILES including time index and Arup logo output
#
# See shadowmovie.man for manual page
#
# Run ExposureCheck before this script
#
# Written by Jeff Shaw, March 1998
# Version 1.1 December 1998
# Time Zone Bug fixed

# Error message
if ($#argv == 0) then
echo "Usage:"
echo "ShadowMovie -a [latitude] -l [longitude] -s [standard meridian]
echo " -z [winter/summer time] -zl [time zone label] -o [octree]"
echo " -x [x pixels] -y [y pixels] -m [month no.]"
echo " -ml [month name] -d [day of month] -dl [date label]"
echo " -t [start time (decimal)] -f [finish time (decimal)]"
echo " -dt [delta time (mins)] -e [picture exposure setting]"
echo -al [arup logo filename] -lp [position of logo]"
echo -ip [position of date and time index]"
echo "The following have default settings as follows:"
echo " -z 0"
echo " -zl"
echo " -x 500"
echo " -y 500"
echo " -d [day; month name]"
echo " -e -6"
echo " -al arup.pic"
echo " -lp tr"
echo " -ip bl"
echo "All other arguments must be set by user for script to run"
echo "Please consult man page and try again."
exit
endif

# Defaults
set ZONE = 0
set LABEL = 
set X = 500
set Y = 500
set EXP = -6
set LOGO = arup.pic
set LOGPOS = tr
set INDEXPOS = bl
set TMF = 1

# Set arguments
while ($#argv > 0)
    switch ($1)
        case -a:
            shift argv
            set LAT = $1
            break
        case -l:
            shift argv
            set LONG = $1
            break
        case -s:
            shift argv
            set MER = $1
            break
        case -z:
            shift argv
            set ZONE = $1
            break
        default:
            echo "Argument $1 not recognized."
            exit
    end
end
#!/bin/csh -f

script to generate sun direction views

to be used for an animation

INITIAL VARIABLE VALUES

set LAT = 32.783
set LON = 96.8
set MER = 1.571
set JD = 265
set START = 6.4
set FINISH = 18.3
set DELTA = 6
set VF = sep.vf

rm -f $VF
set FRAMESPERHOUR = `ev "60/$DELTA"`

set STARTHR = `echo $START | rcalc -e '$1=floor($1)'`
set STARTMIN = `ev "60*$STARTMIN/$DELTA"`

set FINHR = `echo $FINISH | rcalc -e '$1=floor($1)'`
set FINMIN = `ev "60*$FINMIN/$DELTA"`

set COUNTHR = $STARTHR
while ($COUNTHR <= $FINHR)
if ("$COUNTHR" == "$STARTHR") then
set COUNTMIN = `ev "60*$STARTMIN/$DELTA"`
else
set COUNTMIN = 0
endif
if ("$COUNTHR" == "$FINHR") then
set END = `ev "1+(60*$FINMIN/$DELTA)"`
else
set END = $FRAMESPERHOUR
endif
while ($COUNTMIN < $END)
set THISHR = $COUNTHR
set THISMIN = `ev "$COUNTMIN*$DELTA"`
echo "Time - "$THISHR":"$THISMIN
| genvie $LAT $LON $MER $JD $THISHR $THISMIN \ | rcalc -i input.fmt -o output.fmt -f vpar.cal >> $VF

@ COUNTMIN++
end

@ COUNTHR++
end

rshow -kf march.vf -o mar/mar%03d ../site.oct
Arfon Davies
1998 - my first project...
Prado Museum, Madrid
1998 - my first render... using Adeline
Prado Museum, Madrid
1999 - my first render with a man in it...
Millennium Bridge, London
2000 – I discovered C++

Lieven
Back in the old days of Adeline it was possible to do some limited scripts within a DOS batch file, although running in NT made this process very difficult.
Now that DTR has been compiled in NT it is possible to do a vast range of scripts using Win32 Console programs written in Visual C++. Basically, the C++ program is used to generate views, skies, materials, geometry and console command lines which run radiance through the console. Sunviews, animations and all the script examples provided in the Siggraph ’98 course notes and Rendering with Radiance are possible. If you have no knowledge of C++ then now is the time to start learning. Have fun!
Arfon Davies
Ove Arup & Partners
Lighting Consultancy
13 Fitzroy Street
London
W1P 6BQ
T: +44 (0) 20 7465 2649
F: +44 (0) 20 7465 3679
2000 – 1\textsuperscript{st} use of picsun
Picasso Museum, Malaga
2001 – 1\textsuperscript{st} use of climate based analysis
High Museum, Atlanta

1 – Vela
2 – Skylight
3 - Soffitio
2001 – 1st use of sunfactor / suncalc
High Museum, Atlanta

Ewall = (E_{Direct} \times Sunfactor) + (E_{Diffuse} \times DF)

suncalc

Sunfactor %

 Ext (direct)

sf

20%
2001 – 1st use of sunfactor / suncalc
High Museum, Atlanta

Annual exposure – 480 klux.hr

Hourly internal daylight illuminance
2001 – 1\textsuperscript{st} use of suntrace
High Museum, Atlanta
2001 – 1\textsuperscript{st} use of suntrace
High Museum, Atlanta
2003 – 1st use of director
Meier Building @ High Museum, Atlanta
2003 – 1st use of director Meier Building @ High Museum, Atlanta
2003 - 2014

Renaissance
3d models, 100 - 200 MB

8GB ram
1GB HD
2GHz PPC Processor
2 Cores
3,000 Pounds
BRDF before BRDF, an asphalt matter!

**Lambertian**

Longitudinal Uniformity: $U_L = 0.46$

**CIE R3**

Longitudinal Uniformity: $U_L = 0.71$

**CIE C1**

Longitudinal Uniformity: $U_L = 0.69$

**CIE W4**

Longitudinal Uniformity: $U_L = 0.43$
From BRE 209: pen and pencil way to computer age

From 2 caravans to 10,000 windows…
Introducing Computational Design Optimisation to the Radiance world
...looking for an interesting problem

Approximate Flicker Factor, Max = 22% Min = 2% Avg = 10%
and solve it...
like this.
Multispectral analysis of large lighting schemes

An industrial facility with a 160m gas flame in the middle of the sea of turtles...

Key data:
10,000+ light sources
160m gas flame
Large analysis grid (circa 5 x 10 km)
Light levels analysis down to 0.1 lux
Multi-spectral distribution analysis
Unity3d and Radiance

• Timeline - Prado – first rendering
  - Millennium bridge – first render with man in it
- C++
- Picasso Museum – picsun
- High Museum – suncalc + suntrace
- Meier – director movie
Unity3d and Radiance

Recreational swimming
Music with Radiance…
rad2odx - geometry converter

- rad2odx - Converts Radiance polygons to OpenDX geometry format
Annual Daylight Simulation Tools (2009)
\[
\begin{bmatrix}
E_1  & E_{12} & \ldots & E_{1m} \\
E_2  & E_{22} & \ldots & E_{2m} \\
\vdots & \vdots & \ddots & \vdots \\
E_n  & E_{n2} & \ldots & E_{nm}
\end{bmatrix}
= \begin{bmatrix}
DS_{11} & DS_{12} & \ldots & DS_{145} & C_{11} & C_{12} & \ldots & C_{1p} \\
DS_{21} & DS_{22} & \ldots & DS_{245} & C_{21} & C_{22} & \ldots & C_{2p} \\
\vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\
DS_{m1} & DS_{m2} & \ldots & DS_{m45} & C_{m1} & C_{m2} & \ldots & C_{mp}
\end{bmatrix}
\begin{bmatrix}
L_{11} & L_{12} & \ldots & L_{1n} \\
L_{21} & L_{22} & \ldots & L_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
L_{1451} & L_{1452} & \ldots & L_{145n} \\
R_{11} & R_{12} & \ldots & R_{1n} \\
R_{21} & R_{22} & \ldots & R_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
R_{p1} & R_{p2} & \ldots & R_{pn}
\end{bmatrix}
\]

matrixmult skymatrix.dat contribution.dat > result.ill

inputs:
- skymatrix.dat = sky matrix file
- contribution.dat = contribution matrix file

A multiplier can be specified with -m to affect the results for example to convert result to footcandles:

matrixmult -m 0.09267 skymatrix.dat contribution.dat > result.ill
Annual Image Based Analysis (2009)

Annual Daylight Simulation

Luminance
Max = 7000
Mean = 1100
Ratio = 6 : 1
Some tools you can’t do without…
These I brought to LBNL :)

• rgb2lum
  who has memorized

rcalc -e ‘$1=179*($1*0.265+$2*… ?

• weekmask
  When you don’t want to use excel to filter out

\[
\text{weekmask} \ [\text{options}] \ \text{result.ill} > \text{officehours.ill}
\]

<table>
<thead>
<tr>
<th>Options for weekmask</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-e open close</td>
<td>set start and end time for every day (Sun-Sat)</td>
</tr>
<tr>
<td>-d open close</td>
<td>set start and end time for Mon-Fri (daily)</td>
</tr>
<tr>
<td>-s open close</td>
<td>set start and end time for the corresponding day of the week. (s=sunday, m=monday, t=tuesday, w=wednesday, r=thursday, f=friday, a=saturday)</td>
</tr>
<tr>
<td>-m open close</td>
<td></td>
</tr>
<tr>
<td>-t open close</td>
<td></td>
</tr>
<tr>
<td>-w open close</td>
<td></td>
</tr>
<tr>
<td>-r open close</td>
<td></td>
</tr>
<tr>
<td>-f open close</td>
<td></td>
</tr>
<tr>
<td>-a open close</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Hours are given in 24 hour decimal format. 17 = 5pm; 17.5 = 5:30pm. Specifying 0 0 open/close filters out all day. Open/closed specifications are processed in the order that they are given on the command line. For example -e 0 0 followed by -w 9 17 outputs no hours on sat & sunday and 9am -5pm for weekdays.

-\text{-ds start end} \quad \text{Enacts daylight savings time. ‘start’ and ‘end’ are the Julian Dates coinciding with the start and end of daylight savings time.}

-\text{-ds us} \quad \text{‘us’ can be specified for US daylight savings time (64-309)}

-\text{-ds eu} \quad \text{‘eu’ can be specified for European daylight savings time (85-302)}

-\text{-i interval} \quad \text{Sets the input timestep interval to int minutes. Default is 60 minutes.}
Francesco Anselmo
Blender/Radiance User Interface (blender/python)
Latitude: 37.90° North

Weather Analysis and Visualisation Tools (python/scipy/matplotlib)
radmap v. 0.4 / 2011-03-20

- h --help: get help information
- d --defaults: show default options
- v --version: show program version
- l --luxhours: calculate cumulative illuminance, not irradiation
  --sunvangle [angle]: specify sun vertical resolution angle
  --sunhangle [angle]: specify sun horizontal resolution angle
  --skyvangle [angle]: specify sky vertical resolution angle
  --skyhangle [angle]: specify sky horizontal resolution angle
- a, --latitude [n]: specify location latitude (it works only with EPW weather files)
- o, --longitude [n]: specify location longitude (it works only with EPW weather files)
- m, --meridian [n]: specify location meridian (it works only with EPW weather files)
- n, --hour-samples [n]: number of samples per hour
- w, --weather [file]: specify weather data file (can be .epw -EPW- or .tsv -SatelLight)
- s, --skip-lines [n]: skip n lines when reading the weather file
  --no-albedo: no albedo component will be taken into account
  --albedo [rfl]: set average ground reflectance
  --no-sun: don't include sun descriptions (it works only with cumulative skies)
  --genskyonly: generate only cumulative sky (it works only with cumulative skies)
  --sun-efficacy [eff]: set sun efficacy
  --sky-efficacy [eff]: set sky efficacy
  --sky-resolution [res]: set temporary sky images resolution
  --prefix [prefix]: prefix for output files
  --radfile [file]: .rad file to be used
  --viewfile [file]: view file to be used
  --gridfile [file]: grid file to be used
  --optionfile [file]: option file to be used
  -x [res]: output image x resolution
  -y [res]: output image y resolution
  --keep-temporary-maps: don't erase temporary irradiation maps
  --max-kWh [n]: max in kWh scale
  --max-MJ [n]: max in MJ scale
  --max-luxhours [n]: max in luxhours scale
  --cumulative-sky: use the cumulative sky algorithm (default)
  --reduced-cumulative-sky: use the reduced cumulative sky algorithm
  --normalized-maps: use the normalized maps algorithm
Francesco Anselmo pushed to branch **master** at Francesco Anselmo / IFC2Radiance 69665958b Updated ifc2radiance

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / radiance_makefiles 8e41fa0f6 Test

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / IFC2Radiance e30ab537d Test

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / HDR 01daca178 Test

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / radpy a3d5a8d8b Switched to OSX partition

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / radpy e91da9aa8 Added blender scripts

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / radiance_makefiles c9cb118d7 Added photon mapping targets

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / IFC2Radiance 04d6689d6 Fix synchronisation issues

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / HDR 8767b87ac no message

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / IFC2Radiance 558e8dced Added IFC standard Express and XML files

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / IFC2Radiance f80bb8bcd Test

Francesco Anselmo pushed to branch **master** at Francesco Anselmo / IFC2Radiance f3e7ee83 Added ifc python library
Radiance Makefile

The purpose of the Radiance Makefile project is to provide a simplified approach to managing Radiance simulations, with piece support and consistent directory and file naming.

Makefile use

The first thing to do is to download the Makefile and copy it into the working Radiance folder.

After that, you need to edit the file content so that the WORKPATH variable points to the Radiance folder.

Then, run the following command from the unix command line:

```
make dirs
```

Finally, the command to run a simulation is the following:

```
make RADNAME=name VIEWNAME=view SKYNAME=sky MATNAME=material rvu
```

The rvu target can be replaced by one of the following:

```
lumpic
illpic
lumpiece
illpiece
illgrid
dfgrid
```
Materials
Materials
None of the existing lighting pods is located so that the diving pool can be illuminated from this direction.
Daylight design and climate
How to communicate climate based daylight design
How to communicate climate based daylight design
How to communicate climate based daylight design
Daylight and architectural shape
Santiago Torres
BIM before it was called BIM...

1) You need to find point P1 from O.

2) You need to find point P2 from P1.

\[ \text{AIMING VECTOR in plane:} \]
\[ \left( \frac{x}{x^2+y^2}, \frac{y}{x^2+y^2} \right) \text{, right?} \]

To get to P1:

You need to:

- Find the unit projection of the aiming vector in plan,
- Trace back from 'O' by this unit vector multiplied by a luminaire size.

We will have 2 sizes, one for each luminaire, let's put size = 0.6m for now. It will change...
…that worked!
Improving designs / custom louver modelling
Solving the broadcaster riddle
We were there!
We were there!
Correcting issues
Correcting issues
Correcting issues
Correcting issues
Open tools for weather data analysis
Open tools for weather data analysis
Open tools for weather data analysis
Pavlina Akritas
3d models, 100 - 200 MB
8GB ram
1GB HD
2GHz PPC Processor
2 Cores
3,000 Pounds
3d models, 200 - 500 MB

24GB ram
1TB HD
2GHz Intel Processor
24 cores
3,000 Pounds
Designing the roof

louvres
What about the site context?
What is the best option?

...but is this what we want?
What is the best option?
Does it work?

Jumex Museum
2014 - EOF

The future
3d models, ~1GB
24GB ram
1TB HD
2GHz Intel Processor
24 cores
3,000 Pounds
3d models, \(~1\)GB

24GB ram
24GHz Intel Processor
1TB HD

3,000 Pounds

Still the same!

Time to upgrade…
Thank you!