frads

framework for radiance simulation

2021 Radiance workshop, Bilbao, Spain
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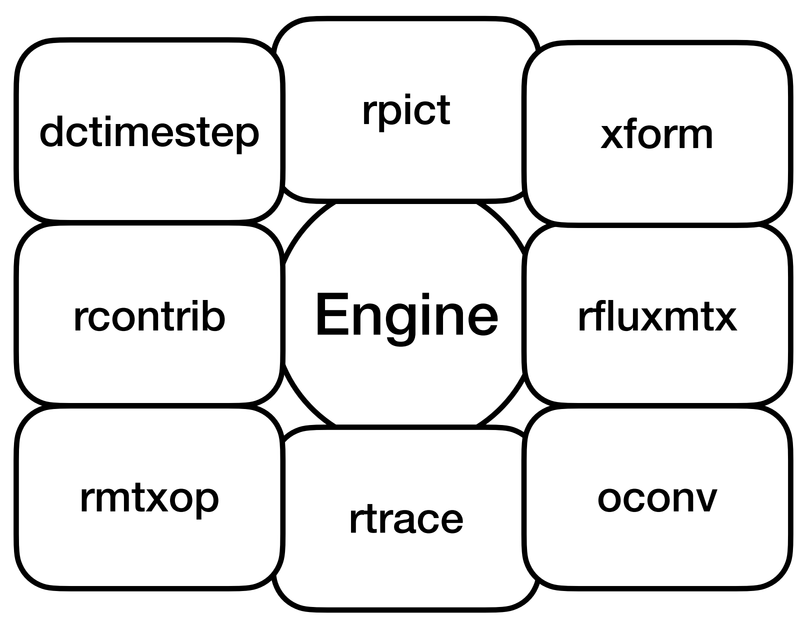
Status

- >30 simulation software tools use Radiance worldwide
- Application: modeling daylight, solar radiation, PV, and more
- Functionality exposed through system calls of a combination of programs: Unix toolbox model



Challenges

- Complicated workflow > user error (difficult to identify)
- Steep learning curve: sampling basis? direction? resolution?
- Slow adoption for advanced modeling capabilities <-> low rate of new tech adoption

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intermediate layer to Radiance core engine

- Standardized workflows
- Workflow automation and scripting (command-line interface + python library)
- Command-line programs: for most of the day-to-day use cases
- Python library: for customized workflow and tool development

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command-line programs

1. mrad: N-phase method simulation
2. genmtx: generic matrix generation
3. genfmtx: generate matrix for non-coplanar systems
4. rglaze: single and double pane glazing modeling
5. dctsnp: matrix multiplication using BLAS linear algebra library
6. geombsdf: geometric BSDF modeling
7. genglazing: system BSDF through WinCalc(WINDOW)

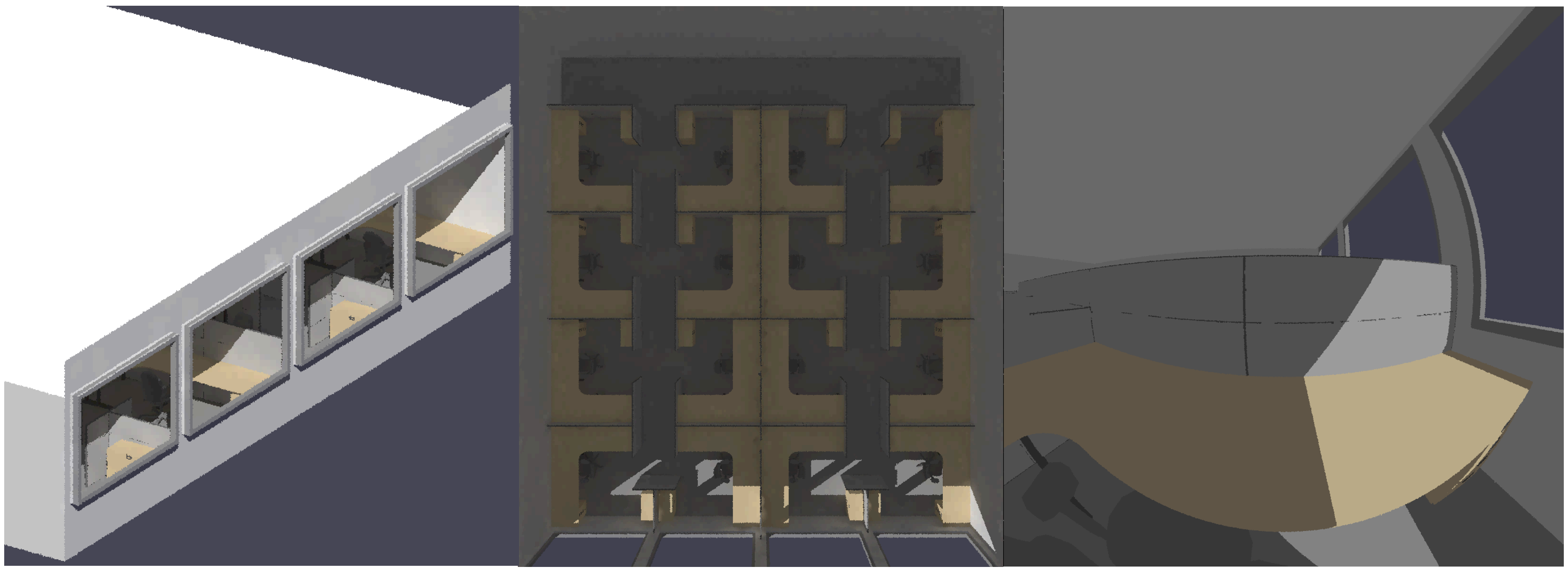
1. mrad

N-phase method simulation

1. Create folder structure:
    - Objects: materials and scene objects
    - Resources: BSDF xml and weather files
2. mrad init
3. mrad run

1. mrad

N-phase method simulation: five-phase example



```
mrad init --latlon 37.7 -122.2 -o '*.rad' -m
'material*.mat' -w '*glass.rad' -g floor.rad .6 .7
```

1. mrad

N-phase method simulation: five-phase example

```
# default.cfg

[SimulationControl]
vmx_basis = kf
vmx_opt = -ab 3 -ad 64
fmx_basis = kf
fmx_opt
smx_basis = r1
dmx_opt = -ab 1 -ad 64 -c 9
dsmx_opt = -ab 1 -ad 262144 -lw 1e-9
cdsmx_basis = r6
cdsmx_opt = -ab 0 -dj 0 -st 0
ray_count = 1
pixel_jitter = 0.7
separate_direct = True
nprocess = 4
overwrite = True
method

[FileStructure]
base = ./
matrices = Matrices
results = Results
objects = Objects
resources = Resources

[Site]
wea_path =
latitude = 37
longitude = 122
zipcode
daylight_hours_only = True
start_hour
end_hour
orientation = 0

[Model]
material = materials.mat
window_paths = lower_glass.rad upper_glass.rad
scene = windowframe.rad overhang.rad ground.rad
extwalls.rad floor.rad desks.rad horframe.rad
cubefabric.rad deskleg.rad ceiling.rad cubeframe.rad
chairs.rad walls.rad
ncp_shade
window_xml = blinds30.xml klems_aniso_high.xml
window_control = 0 1
window_cfs

[Raysenders]
view = -vf v1a.vf -x 800 -y 800
grid_surface = floor.rad
grid_height = 2.5
grid_spacing = 2
```

1. mrad

N-phase method simulation: five-phase example

```
mrad run default.cfg
```

Illuminance and luminance results will be produced
in the "Results" folder

Demo

2. genmtx

generic matrix generation

```
>> genmtx -h

Generate flux transport matrix

optional arguments:
  -h, --help            show this help message and exit
  -st {s,v,p}           Sender object type: (s)urface, (v)iew, (p)oint
  -s SENDER             Sender object: view | grid point | .rad file
  -r RECEIVER [RECEIVER ...]
                        Receiver objects, sky | sun | *.rad files
  -i OCTREE             Scene octree file
  -o OUTPATH [OUTPATH ...]
                        Output file path | directory
  -env ENV [ENV ...]    Environment files
  -rs {r1,r2,r4,r6,kf,sc25}
                        Receiver sampling basis, ....
  -ss SENDER_BASIS      Surface sender sampling basis: kf|r1|r2|..
  -ro RECEIVER_OFFSET   Move receiver surface in normal direction
  -so SENDER_OFFSET     Move sender surface in normal direction
  -opt OPTION           Simulation parameters enclosed in quotes
  -rc RAY_COUNT         Ray count
  -res RESOLU RESOLU    Image res., defeault=[800, 800]
  -smx SMX              Sky matrix file
  -wpths WPTHS [WPTHS ...]
                        window files paths
  -v, --verbose         verbose mode
```

2. genmtx

generic matrix generation: example

- **View matrix:**
  `>> genmtx -s grid.pts -st p -r window.rad -ro 0.05 -env material.mat room.rad -o view.mtx`

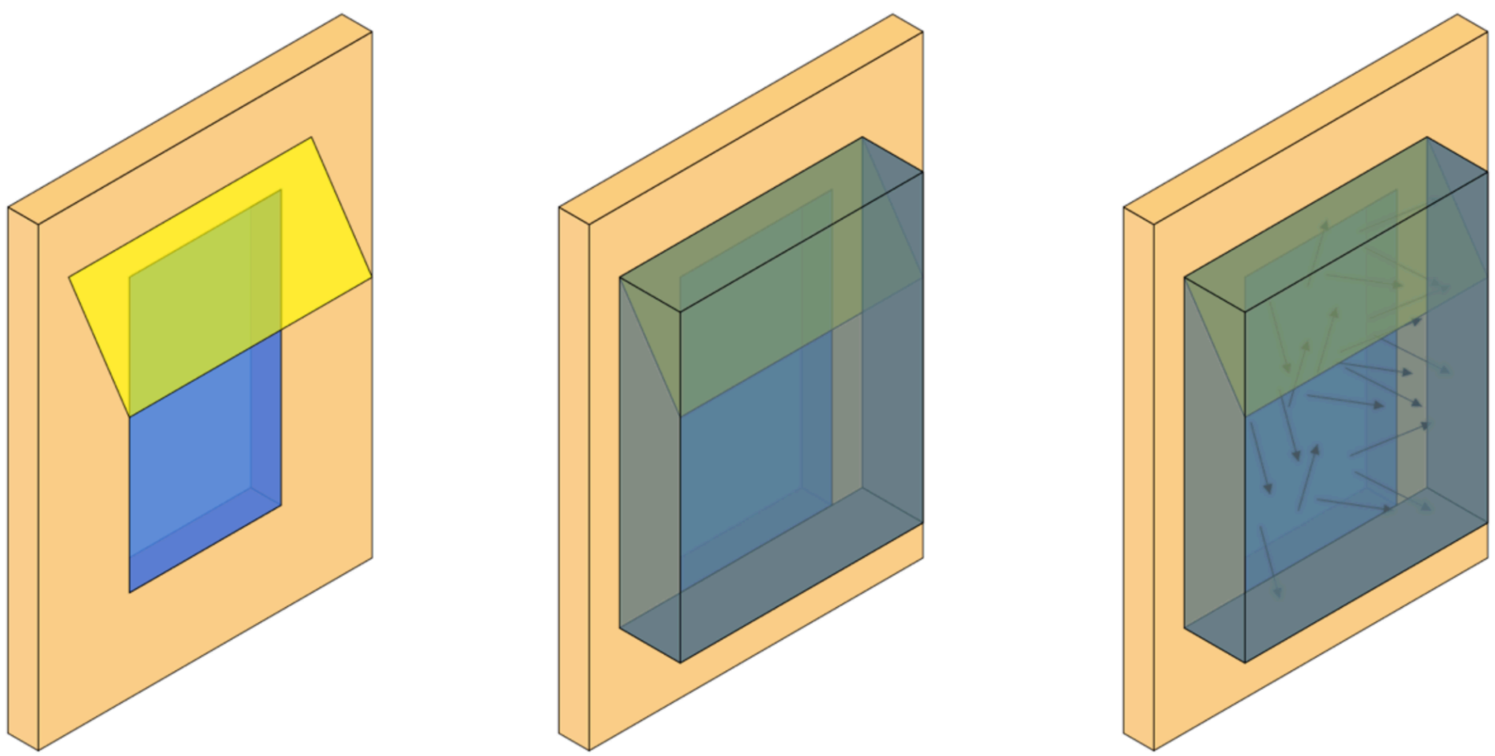
- **Daylight matrix:**
  `>> genmtx -s window.rad -st s -so -0.05 -ss kf -r sky -rs r4 -env material.mat room.rad -o daylight.mtx`

- **Direct sun view matrix** with sun and window culling:
  `>> genmtx -s view.vf -st v -r sun -rs r6 -env material.mat room.rad window.rad -o sun_r6.mtx -smx oak_sun.smx -wpths window1.rad window2.rad`

3. genfmtx

non-coplanar system modeling

```
>> genfmtx -w window.rad -ncp awning.rad -rs r4
-ss r4 -opt '-ab 1 -ad 4096 -c 5000' -env
material.mat wall.rad -o awning.mtx
```



4. rglaze

glazing unit modeling

- Uses Optics files or accesses directly from IGSDB database
- Allows user to specify color space
- Example
  - `rglaze -X layer1.optics layer2.optics`
  - `rglaze -D 4789 8765 -T $igsdb_api_token`
    - `*igsdb id`

4. rglaze

glazing unit modeling

```
>> rglaze -X CLEAR_6.DAT CSR42_3.afg
```

```
void BRTDfunc Generic_Clear_Glass+Comfort_Select_R-42_on_Clear

if(Rdot,cr(fr(0.115330976),ft(0.714477533),fr(0.0769209297)),cr(fr(0.0769222478),ft(0.855362931),ft(0.173130587)))

if(Rdot,cr(fr(0.148201345),ft(0.722440685),fr(0.0813256)),cr(fr(0.0813254108),ft(0.893129389),fr(0.21087446)))

if(Rdot,cr(fr(0.248413717),ft(0.631038374),fr(0.0828252871)),cr(fr(0.0828252771),ft(0.885143028),fr(0.28307956)))

ft(0.714477533)*ft(0.855362931)

ft(0.722440685)*ft(0.893129389)

ft(0.631038374)*ft(0.885143028)

0 0 0 glaze2.cal

0

9 0 0 0 0 0 0 0 0 0
```

5. dctsnp

matrix multiplication with numpy

- Use numpy (BLAS) to accelerate matrix multiplication
- Takes regular Radiance matrix as inputs (ascii, float, double, xml), RGB weighting built-in
- No image-based matrix
- Example use:
  - `dctsnp -m view.mtx shade.xml daylight.mtx -s sky.mtx -w 47.4 119.9 11.6 -o output.txt`

6. geombsdf (wip)

geometric BSDF generation and modeling

- Blinds or any customized macroscopic shading system
- BSDF created using either:
  - genblinds
  - Custom cross section (novel blind shape)
  - Custom periodic shape
- Automated BSDF generation with proxy geometry
- Places BSDF onto the window

7. genglazing (wip)

calls WINDOW to generate system BSDF

- Create BSDF for multilayer glazing and shading system
- Uses pyWincalc python library which calls Window_CalcEngine (the engine behind WINDOW)
- Can be connected to IGSDB API to pull data directly from glazing and shading database
- Configuration file enables scriptable, transferable, repeatable glazing+shading system modeling

7. genglazing (wip)

calls WINDOW to generate system BSDF

User generated double_lowe.cfg file

[Standards]
optic_standard = standards/W5_NFRC_2003.std

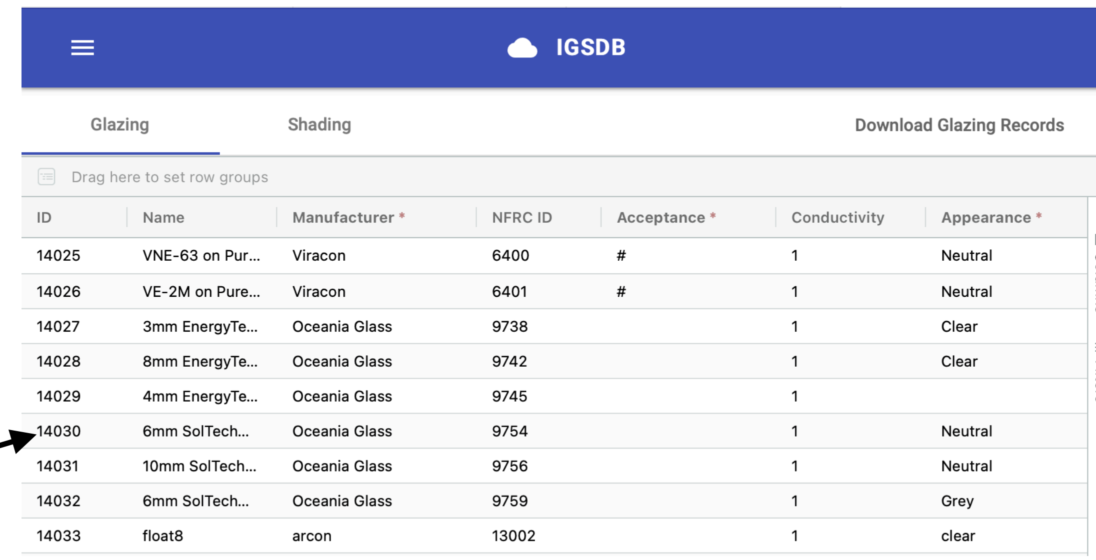
[Blinds]
blind1 = 0.03 0.03 45 0 13919 # spacing depth tilt curve material_igsdb_id

[Shade]
shade1 = 13810 # silverscreen 2%OF black
shade2 = 13227 # helio 3%of grey
shade3 =

[Glazing]
# glazing1 = 7972
glazing1 = ./products/CSR42_3.afg
glazing2 = 5216
glazing3 =
glazing4 =

[Gap]
gap1 = 0.0127 air
gap2 = .0127 air
gap3 =

[Glazing system]
width = 1
height = 1
system = glazing1 gap1 glazing2 gap2 shade1 # ext -> int



ID	Name	Manufacturer *	NFRC ID	Acceptance *	Conductivity	Appearance *
14025	VNE-63 on Pur...	Viracon	6400	#	1	Neutral
14026	VE-2M on Pure...	Viracon	6401	#	1	Neutral
14027	3mm EnergyTe...	Oceania Glass	9738		1	Clear
14028	8mm EnergyTe...	Oceania Glass	9742		1	Clear
14029	4mm EnergyTe...	Oceania Glass	9745		1	
14030	6mm SolTech...	Oceania Glass	9754		1	Neutral
14031	10mm SolTech...	Oceania Glass	9756		1	Neutral
14032	6mm SolTech...	Oceania Glass	9759		1	Grey
14033	float8	arcon	13002		1	clear

igsdb.lbl.gov
alfa stage

```
genglazing double_lowe.cfg -T
$igsdb_token -M
```

System BSDF (.xml) will then be generated

Other tools

- ep2rad: converts EnergyPlus model (epjson) to Radiance models
- genradroom: generates a side-lit shoe box model
- gengrid: generates a sensor grid base on a horizontal surface
- getwea: gets the .wea file from lat/lon, or zipcode(US)

Python library

Example: flip window surface normal by modifier

```
from frads import radutil
windows = radutil.unpack_primitives(“windows.rad”)
for window in windows:
   polygon = radutil.parse_polygon(wall.real_arg)
   if window.modifier == 'white60':
      new_polygon = polygon.flip()
      new_primitive = radutil.Primitive(
                        wall.modifier, wall.ptype, wall.identifier,
                        wall.str_arg, new_polygon.to_real())
      print(str(new_primitive))
```

More: https://frads.readthedocs.io/en/latest/api.html

Thank you

Documentation: http://frads.readthedocs.io/

To install:

```
pip install frads
```

or for head

```
pip install git+https://github.com/LBNL-ETA/frads
```

Beta users welcome!!!

contact: taoningwang@lbl.gov

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