Irradiation modelling with cumulative skies

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Irradiation modelling is not new...

Compagnon: aggregate results from simulations at discrete points [rtrace].

Cumulative sky modelling

\[ \ell_i = f(Z, \theta) \]

\[ \chi = I_{dh} \left/ \sum_{i=1}^{p} \ell_i \Phi_i \sin \overline{\gamma}_i \right. \]

\[ R_i = \ell_i \chi \]

\[ R_i^T = \sum_{j=1}^{n} R_{i,j} \]
Solar radiance

1. Global sky radiance distribution  \[ R_i = R_{di} + I_{bi} / \Phi_i \]

2. Binned sun positions and scaled radiance [\(-dt=0\)]

3. (sub)Hourly sun positions [small \(\Phi_s\)]
Comparisons
A street canyon in Oslo...

Hourly simulation
Cumulative – global radiance distribution (145 patches)

<table>
<thead>
<tr>
<th>Method</th>
<th>RMS error, %</th>
<th>Relative run time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hourly simulations</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Diffuse discretised sky, binned suns</td>
<td>1.2</td>
<td>1/180</td>
</tr>
<tr>
<td>Global discretised sky</td>
<td>2.2</td>
<td>1/1130</td>
</tr>
</tbody>
</table>

Cumulative – binned suns

Cumulative – global radiance distribution (577 patches)
Applications
Pelham place - Hastings [F+P]

external irradiation
Rive Gauche – Paris [1A]
temporal mean external illumination

\[ L_i = R_i \eta_d \]

Or lux-hours
Hackney city academy [RRP]
internal irradiation / solar visibility hours

\[ R = \left( \Phi \sin \gamma \right)^{-1} \]
National Assembly for Wales [RRP]
internal solar visibility hours
Louvres reduce energy transmitted by ~26%
Conclusions

• Pre-processing cumulative skies is:
  - Computationally efficient
  - Reasonably accurate

• The principal has been applied to predict:
  - Solar irradiation
  - Solar visibility hours
  - Temporal mean illuminance

• It could be applied to study daylight availability

• But there is no substitute to multiple simulations if temporal information is required
Thank you!