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High Impact Projects
Software Stack

Building first-class research infrastructure
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1 Introduction

This document describes the software stack used in the preparation of the solar radiation potential for the city of Kalgoorlie/Boulder. Additionally, the document discussed how the project could be extended to other locations.

2 Software Stack

All software used in the stack is open source. A variety of packages are used in combination to achieve the required output. The 'Dataset Description and Usage Examples' document describes the data sets and provides examples of usage.

The input data required for the process is as follows:

- Footprints geometry. This study is based on the 'Bing footprints for Australia' available from `https://github.com/microsoft/AustraliaBuildingFootprints`. The data is licensed under the Open Data Commons Open Database License (ODbL) `https://opendatacommons.org/licenses/odbl/` licence. The current (2023) data set's vintage "is anywhere from 2013 to 2018, with the majority being from 2018" *Microsoft/Australian Building Footprints* (2022).
- Climate file in EPW format: Weather Data based on temperature and irradiation from `https://climate.onebuilding.org`. For this study, the AUS_WA_Kalgoorlie-Boulder.AP.946370_TMYx.2004-2018.zip climate file was used.
- Material file and Sky Files: These two files are specific files required by the black box Radiance calculation engine. (See section 3 for details.)

The Bing footprint data is available in GeoJSON format (see `https://geojson.org/`). There are many software programs, both open source and proprietary, that can read this format. See `https://gdal.org/software_using_gdal.html#software-using-gdal`. For example:

- Qgis: `https://www.qgis.org/en/site/`
- GDAL: `https://gdal.org/index.html`

See Figure 1 for the sequence of steps required to generate the solar radiation potential of the footprints.

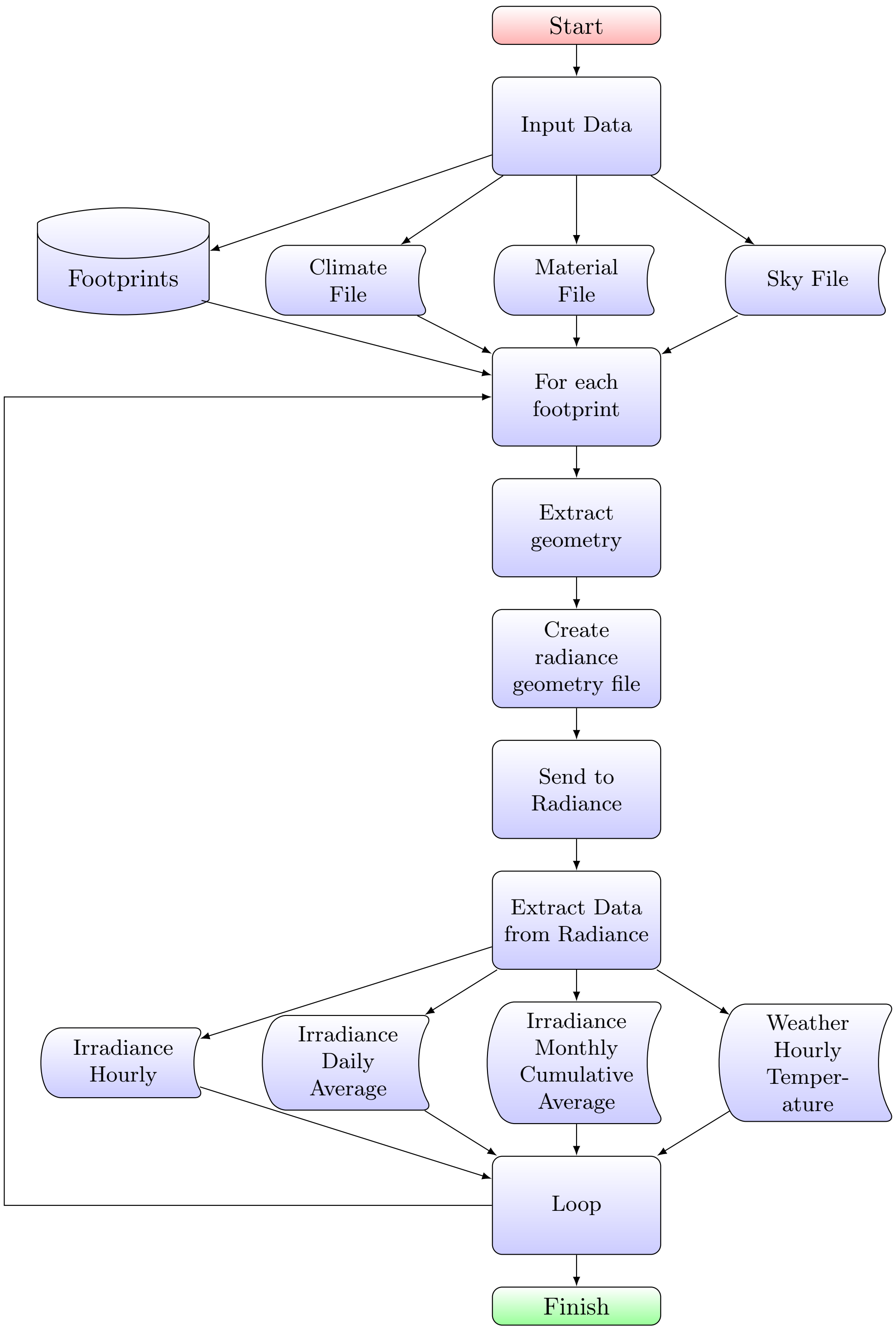

Figure 1: Schematic of Footprint Irradiance Calculations

3 Calculation Engine

To predict the amount of solar radiation at a specific point above a reflecting plane, the model is rendered using the Radiance Lighting Simulation Suite (referred to as *Radiance* in this document and available via https://www.radiance-online.org/). *Radiance* is an open source software capable of predicting physical accurate lighting levels on any plan Apian-Bennewitz (2004). Predictions using the Radiance Lighting Simulation Suite have been validated by a number of authors Mardaljevic (1995, 2000, 2001); Reinhart and Andersen (2006).

The technique used to generate the total solar radiation potential for each footprint utilises a modified 3-phase method (https://www.radiance-online.org/learning/tutorials/matrix-based-methods) as noted by Brembilla, Chi Pool, Hopfe, and Mardaljevic (2017). The interior matrix is deleted in this application. The methodology creates a sensor point at the centroid of the roof segment. The weather file (see http://climate.onebuilding.org/) associated with the project's longitude/latitude is used to create a 2305 sky patches based on the Perez (Perez, Seals, Ineichen, Stewart, & Menicucci, 1987; Perez, Seals, & Michalsky, 1993) all weather model and hourly intervals.

A typical mid-performance solar panel is used to predict the number of panels that can be fitted into the footprint geometry. (Please see the 'DataSet Information' document for panel details - Table 1).

The area of the maximum number of panels, layout orientation options are vertical or horizontal, are multiplied by the simulated monthly totals to compute the potential roof segment's solar potential. The contribution of each panel takes into account the panel size, efficiency and temperature coefficient Pmax (air temperature variation about 25°C).

From the hourly simulated values, the monthly totals are computed as $\mathrm{kW/m^2}$.

To compute the average monthly contribution, the number of daylit hours for each month are compiled from the weather file and then used to compute the hourly averages.

See the *Radiance* documentation at http://radsite.lbl.gov/radiance/refer/refman.pdf for further details of the parameters and usage of the following two files.

The material definition for the footprint is as follows:

```
# Material:

void plastic Material_Roof_segment
0
0
5 0.4 0.4 0.4 0 0
```

The sky definitions is as follows:

```
#@rfluxmtx h=u u=Y
void glow groundglow
0
0
4
   1 1 1 0

groundglow source ground
0
0
4
   0 0 -1 180

#@rfluxmtx h=r4 u=Y
void glow skyglow
0
0
4
   1 1 1 0
```

```

skyglow source sky
0
0
4
   0 0 1 180
```

4 Copyright Information

For copyright licences of the various input datasets, please refer to the 'Dataset Description and Usage Examples' document.

5 Extend to Other Locations

To extend this project to other locations, it is necessary to replicate the steps shown in Figure 1. The implementation of the complete flowchart is dependent on the operating system, software and data management software being used.

1. Choose a climate file, in an appropriate format for your software engine, which is representative of the footprint's location.
2. Construct the footprint's geometry file.
3. Construct the material and sky files as required by your methodology.
4. Send the data to the *Radiance* engine or other software engine for processing.
5. Extract the required solar irradiance results.
6. Determine the number of solar panels that can be placed on the footprint.
7. Convert and record the solar irradiance results to solar potential. See table 1 and equation 1 of the 'Dataset Description and Usage Examples' document for guidance on the solar panels used in this study and conversion of the irradiance to potential.

6 Bibliography

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