

Improving reproducibility in building simulation: a pure-Python approach to geometry creation

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2021-06-23

My background

- I joined Loughborough University in 2008
- My job title is Reader in Building Performance Modelling
- I teach building simulation, energy data analysis, sustainable building design and renewable energy.
- I was a member of the University's Open Research Working Group in 2019.
- I was awarded the CALIBRE Winter 2019 Award for Open Research
- In 2015 I published the Refit Smart Home dataset on the University's Data Repository (14,307 views, 3,997 downloads)
- I publish papers on FAIR data and open research methods using Python and Jupyter Notebooks
- I maintain the GitHub pages for the Building Energy Research Group

The problem I am trying to solve

- **Task:** I would like *to construct a building simulation model* of a 4 bed house and *to simulate the energy performance* of the house using the EnergyPlus software.
- **Challenge:** I would like to do this in an *open, transparent* way so that the whole process is *reproducible*.

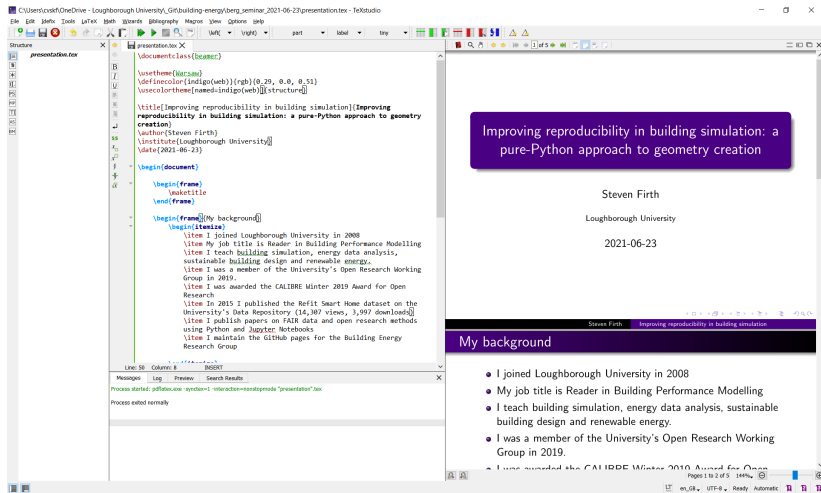
What is "Reproducible"?

The Alan Turing Institute in its publication 'The Turing Way' defines reproducible research for data science as:

Work that can be independently recreated from the same data and the same code that the original team used.

An Example of Reproducibility

This presentation is reproducible as it is written in code (Latex)



An Example of Open Reproducibility

This presentation is also open as the code is hosted on the BERG Github repository

The screenshot shows the GitHub interface for the repository 'building-energy / berg_seminar_2021-06-23'. The repository is owned by 'stevanfirth' and has 3 commits. The file list includes:

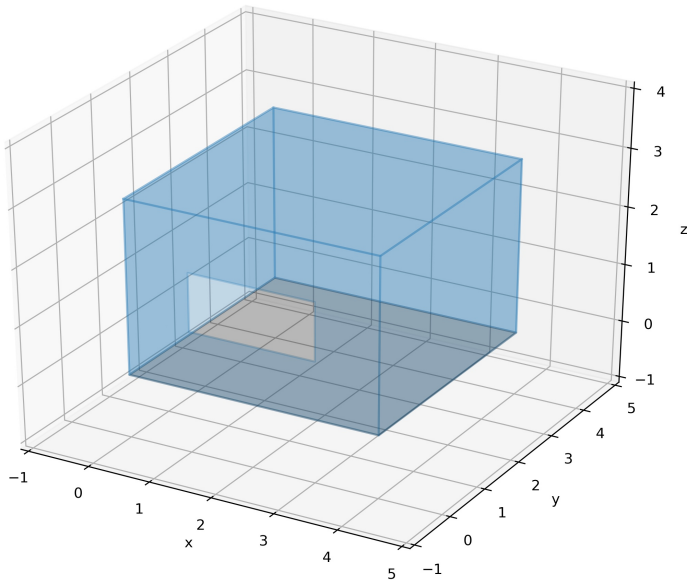
File	Commit	Time
.gitignore	Initial commit	4 hours ago
LICENSE	Initial commit	4 hours ago
README.md	Initial commit	4 hours ago
latex_example.png	Updates	18 seconds ago
presentation.aux	Updates	32 seconds ago
presentation.nav	Updates	32 seconds ago
presentation.out	Updates	32 seconds ago
presentation.pdf	Updates	32 seconds ago
presentation.snm	Updates	32 seconds ago
presentation.synctex.gz	Updates	32 seconds ago
presentation.tex	Updates	32 seconds ago
presentation.toc	Updates	32 seconds ago
presentation.vrb	Updates	18 seconds ago

The README.md file is selected, showing the title 'berg_seminar_2021-06-23' and the description: 'Repository with latex source for the presentation 'Improving reproducibility in building simulation: a pure-Python approach to geometry creation'.'

Point-and-click vs. Text-based commands

Research task	Point-and-Click		Text-based Commands
Writing documents	Microsoft Word,	Apple Pages	L ^A T _E X
Creating slides	Microsoft PowerPoint,	Apple Keynote	L ^A T _E X
Analysing data	Microsoft Excel,	Google Sheets	Python and Jupyter Notebooks
Building websites	Adobe Dreamweaver		HTML, Bootstrap, Django

Geometry Creation - Case Study



Creating geometry using Python

```
1  import pybim.gbxml601
2  bim = pybim.gbxml601.BIM(id='bim1')
3  campus = bim.add_campus(id='campus1')
4  building = campus.add_building(id='building1')
5  space = building.add_space(id='space1',
6      floor_polygon=((0.0, 4.0, 0.0),
7                    (4.0, 4.0, 0.0),
8                    (4.0, 0.0, 0.0),
9                    (0.0, 0.0, 0.0)),
10     extrud_vector=(0.0, 0.0, 3.0)
11 )
12 surface = campus-surfaces(space_inner='space1',
13                             space_outer=None,
14                             azimuth=180.0)[0]
15 opening = surface.add-opening(id='opening1',
16                                polygon=((1.0, 1.0),
17                                         (3.0, 1.0),
18                                         (3.0, 2.0),
19                                         (1.0, 2.0))
20 )
```

Conclusions

- ① Reproducibility involves writing text-based commands, i.e. code, scripts, programming etc.
- ② The challenge in developing building simulation models using text-based commands is the 3D geometry of the building model.
- ③ New open source libraries and packages are required for tasks such as:
 - Doing geometry calculations (i.e. 3D polygon intersection, 3D polyhedron intersection)
 - Working with BIM models that contain geometric and non-geometric data (construction, internal gains etc.)
 - Interfacing with standard building simulation file formats (gbXML, idf, epJSON)