Evaluation of Semi-Automated BIM-BEM Data Transfer Tool BIM2SIM

Benjamin Golla
Mentor: Dr. James O'Donnell

UCD School of Mechanical and Materials Engineering

INTRODUCTION

Integral to the timely delivery of energy-efficient infrastructure in a carbon-aware future is the **Building Energy Performance Simulation (BEPS)**, an analytical model of a building's energy performance that is necessary for informed decisions regarding sustainable design, development, and maintenance throughout the unit's life.

The information required for this important tool's function is ideally sourced from a **Building Information Model (BIM)** that should contain a comprehensive set of spatial, geometric, and material data relevant to the building's energy consumption. [1]

The semi-automated exchange of data between architectural BIM-based designs and BEPS has been proposed as a solution to the problem of extensive manual and error-prone revision required for the creation of robust energy simulation. [2]

RESEARCH AIMS

- Test the reproducibility of existing data transfer results from **BIM2SIM**, a BEPS generation tool, for a given BIM model.
- In much the same way, assess the **IFC2SB** tool's functionality in generating proper space boundaries from input IFC files.
- Identify technical limitations and gaps in existing documentation that limit usage of both BIM2SIM and IFC2SB in facilitating adequate data transfer across multiple use-cases.

METHODOLOGY

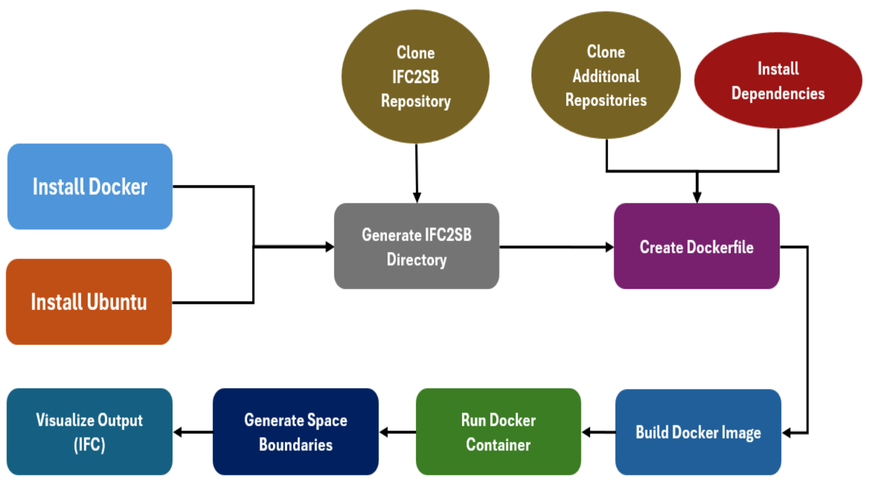
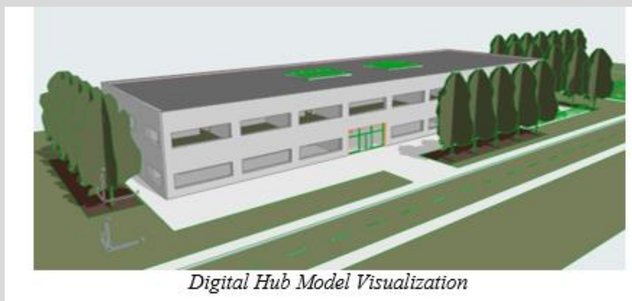


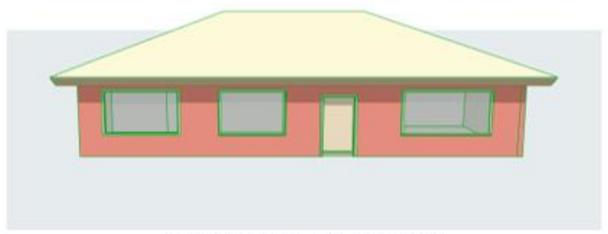
Figure 1: Process Flow Diagram for IFC2SB Tool

- Using the Digital Hub BIM Model as an input, the IFC2SB workflow was executed in Ubuntu from installation of requisite software to a build-out of the space boundary generation tool. Programmatic errors and inefficiencies were documented at each step in the process.

This research evaluated the tools in question using two building models produced in Graphisoft Archicad: Aachen University's Digital Hub for replication of documented results and a residential archetype of a Bungalow for further tool validation



Digital Hub Model Visualization



Bungalow Model Visualization

Figure 3: Experimental BIM Model Visualizations

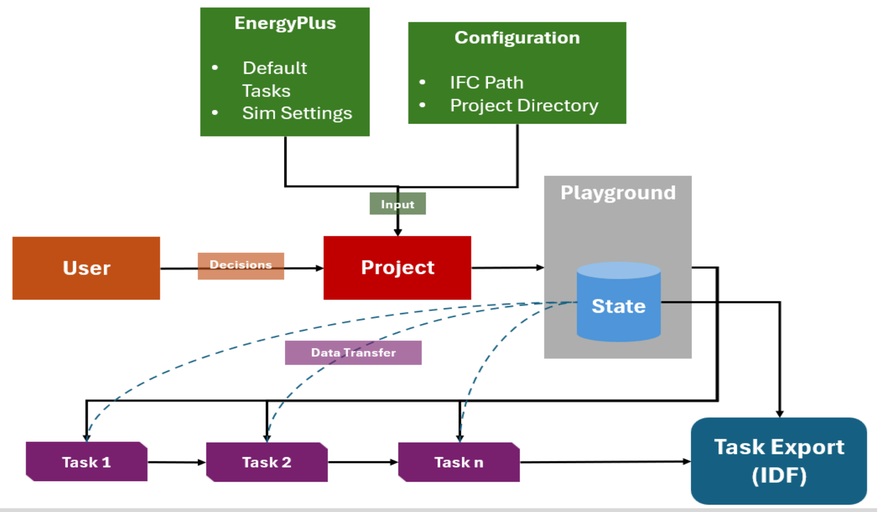


Figure 2: Process Flow Diagram for BIM2SIM Tool

- In an attempt to replicate pre-existing EnergyPlus results, an enriched form of the Digital Hub BIM was used as an input for BIM2SIM. The workflow was executed in Git Bash from user creation of a project in Python to completion of programmatic tasks. The process was repeated for the Bungalow. Errors and inefficiencies were documented at each step.

RESULTS

Error	Solution
Communication failure between Docker Desktop and WSL (Windows Subsystem for Linux)	Total regeneration of Dockerfile, re-installation of dependencies
Missing Qt5 base development libraries in IFC2SB directory	Manual installation within IFC2SB directory
Missing CMakeLists.txt source code in IFC2SB directory	Re-cloned IFC2SB repository into working directory
Missing OpenCASCADE, IfcOpenShell dependencies	Manual installation of both software outside of Docker Image Build, inside IFC2SB directory
Missing JSON for Modern C++ library, OpenCOLLADA repository, "code" subdirectory	Manual installation/cloning outside of Docker Image Build, inside IFC2SB directory
Fatal C++ error, termination of Docker Image Build	Unresolved

Table 1: Summary of IFC2SB Tool Build Errors

Error/Warning	Description	Criticality
RuntimeWarning: invalid value encountered in scalar divide	Invalid operation, such as division by zero or a NaN value, in the code. This may generate incorrect calculations but does not immediately stop execution.	Low
[USER-INFO]: Replacing ___ with ___ for disaggregated element	An informational message about the replacement of one element with another based on space boundary (SB) information. This is an internal change and not an error, but it can indicate that the model structure is being adjusted.	Low
[DEV-WARNING] - Total of 49 space boundaries removed	49 space boundaries were removed during processing. This suggests that those boundaries may have been deemed invalid or unnecessary for the simulation. While not critical, it may impact the model's accuracy.	Medium
[DEV-ERROR] - Large deviation in net bound area for SBs	An error indicating significant discrepancies in the boundary area for space boundaries (SBs). This could cause serious issues in the spatial configuration, potentially leading to incorrect results in energy simulations.	High
AssertionError: Not enough answers provided.	The program expected answers to be provided for a decision but didn't receive them. This error halts execution and requires attention, as the program cannot proceed without resolving this issue.	High
TypeError: 'NoneType' object is not iterable	An error that occurs when the program attempts to iterate over a None object, which is typically a result of missing or incorrect data. This halts execution and must be fixed to allow the program to run.	High

Table 2: Overview of Frequently Encountered BIM2SIM Errors

DISCUSSION / CONCLUSIONS

- The IFC2SB installation process resulted in critical failure due to recurring issues with the exchange of information (dependencies, libraries, etc.) between associated software and load requirements. These challenges were exacerbated by limited documentation for troubleshooting purposes.
- BIM2SIM's workflow, while more procedural in nature, was not successfully executed due to inadequacies in the input IDF and process-related errors. Unclear feedback made it difficult to interpret issues with the tool's outputs and move forward with BEPS generation.
- The development of user-friendly model quality checking tools for use prior to running a BIM-BEPS transfer could correct common errors associated with IFC file inputs and inform users of BEPS-relevant contents of their models.
- Both tools would benefit from use-case guides walking the user through the replication of successful workflow procedures and their underlying assumptions.
- Given difficulties with receiving and interacting with decisions in BIM2SIM, a more versatile mechanism that seeks out missing information and provides coherent prompts for user input across many different BIM models would increase the tool's overall usability
- Further standardization of the data transfer process and its required inputs may prove to increase reliability of tools and inform decisions upon the creation of BIMs.

REFERENCES

[1] O'Donnell, J. T., Maile, T., Rose, C., Mrazovic, N., Morrissey, E., Regnier, C., Parrish, K., and Bazjanac, V. (2013). Transforming BIM to BEM: Generation of Building Geometry for the NASA Ames Sustainability Base BIM.

[2] Van Dessel, M., Maile, T., and O'Donnell, J. (2019). BIM to Building Energy Performance Simulation: An Evaluation of Current Transfer Processes. *Proceedings of the 16th IBPSA Conference*, Rome, Italy.