Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Yangyu Liu
Student number	5777453

Studio		
Name / Theme	Building technology graduation studio: Design informatics	
Main mentor	Dr. Azarakhsh Rafiee	AE+T: Digital technologies
Second mentor	Dr. Eleonora Brembilla	AE+T: Environmental and climate design
Argumentation of choice of the studio	Design informatics and Climate design are the directions I'm most interested in at BT, and I'd like to use digital tools and technology to do some research on buildings and their surroundings.	

Graduation project	
Title of the graduation project	Cloud-based room-centric daylight simulation application for environment design and renovation: a case study using the BIM model of TU Delft architecture faculty.
Goal	
Location:	TU Delft architecture faculty building and its surrounding
The posed problem,	In the field of urban planning and building renovation, evaluating the impact on existing space through daylighting simulations is a crucial endeavor. However, the current daylighting simulation workflows face certain challenges. They are heavily relied on specific software, involve complex procedures that are difficult to use widely in teams, lack integration with GIS information, have to select rooms manually, and require a high level of specialization and user expertise.
research questions and	Main RQ: To what extent can a webpage application do per-room basis daylight analysis on BIM models in a user-friendly way that effectively

	demonstrates the impact of dynamic changes in building components and urban context? Sub RQ1: Which elements of building components and the urban context should be considered and configured as parameters, and how can users easily interact with them through the interface? Sub RQ2: What are suitable daylight metrics for assessing indoor daylight performance on a per-room basis, and how can the results and their variations be effectively visualized? Sub RQ3: How can 3D city models and BIM model be loaded into Rhino for optimal compatibility to run Honeybee daylight simulation, and how can they be loaded on the application for displaying and interaction? Sub RQ4: How can BIM information be used to smartly recognize components per room, enabling an automatic integration with daylight simulation? Sub RQ5: How do different LODs of 3D city and BIM models impact the computation accuracy and time, and how to make the overall workflow more efficient?
design assignment in which these result.	The design task is to create an innovative cloud-based daylight simulation tool. This application enables room-specific simulations based on a BIM model, allowing users to interact with and modify both the urban environment (such as adding or removing buildings, adjusting heights, and roof types) and the building itself (changing materials of important components, adding various shading devices, etc.). Users can visualize the impact of these changes on indoor

	daylight performance from both indoor and outdoor perspectives. In order to enhance user experience, the tool incorporates a user-friendly interface with dropdown menus, checkboxes, sliders, and 3D axes control within a webGL-based 3D map, providing comprehensive GIS information. After that, this research will validate the tool's functionality and improve its efficiency by improving the overall workflow and details. Ultimately, its goal is to function as a valuable tool for visualizing daylight performance, providing insights and suggestions for designers, urban planners, architects, and building owners involved in environmental design and building renovation.

Process

Method description

To answer the main and sub-research questions, a combination of methods will be followed.

Firstly, through literature research, reading documentation, and analysis of example projects, emerged as the preferred modeling software over Revit regard this research purpose. Rhino has better compatibility and provides more parametric space that allow BIM and GIS integration, and capable for cloud-based daylight simulation, getting both visual and numerical result. Functioning as Rhino's API, the Rhino compute technique is selected and the possible interactive options (webGL-based platforms, webpage, and game engine) are compared to align with the purpose and user interaction freedom required for the design assignment. After thorough research, it's determined that webGL application or webpage are the most suitable options, as game engines like Unity lacks documentation for working together with Rhino Compute and is already being developed for commercial use.

Secondly, daylight metrics are selected for the tool's dashboard for room-based simulations. The selection is based on building codes, GREEN certificates, and state-of-art research. Basic daylighting simulation scripts were created in Honeybee and new metrics scripts will be coded according to their physical definition. Similarly, indoor and outdoor parameters and components affecting daylight are selected through literature research, and new options provided in the tool are based on Dutch standards and common practices. Examples from Rhino Compute are referenced and possibilities for user interaction are considered according to the needs of the selected components.

Thirdly, the BIM model of TU Delft architecture faculty is used as a case study, the surrounding buildings are integrated into Rhino as cityGML with low LOD, processed using Grasshopper and reconstructed for Honeybee simulation. The workflow and mapping between the cityGML data and Honeybee input parameters will be guided by literature research. User interactions were implemented using Grasshopper scripts, Javascript, and HTML to connect Rhino Compute to a web browser. Sample projects were researched and demos were created for the integration workflow.

Next, the BIM model was managed through Dynamo and Rhino.inside.Revit, and each room was labeled to integrate all data into Rhino. This is a single-time process, guided by literature research results on the workflow of related projects. Then the BIM model will be scripted into two parts, and sending non-geometric attribute data in JSON format, 3D geometric data in glTF format, The element IDs of the two parts are linked to each other, and IFC and WGS coordinates are integrated using Javascript and displayed in the web browser. As there isn't a clear approach in any projects for incorporating Rhino Compute with the web viewer's workflow, this aspect poses a unique challenge. In case of time constraints, an alternative plan involves loading and interacting with the BIM model on a webpage, along with the broader 3D city model of low LOD to be used as a 3D map environment.

Finally, due to the limitation of time, a survey with potential users will not be included. Instead, several per-room daylight analyses will be conducted to test the tool's functionality, to show the impact of possible indoor and outdoor changes to room daylight performance. Improvements to the workflow will be carried out, such as the way of sending geometry, detail level of running daylight simulation result, LOD of loaded city geometry will be compared and discussed to ensure greater tool efficiency. Suggestions about scaling up the research on other BIM models also be presented.

Literature and general practical references

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Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?

Building technology track always encourages us to create smart buildings that are sustainable, comfortable and environmentally intelligent, this research is focusing on automating workflows, enabling cloud capabilities, enhancing integration with urban information, and creating user-friendly interactive daylight simulation tools. It helps lowering the barrier of simulating indoor daylight performance and get the result in a faster way, and can provide designers an option to directly see how the change on building properties itself and its surrounding environment impact on the daylight comfort indoor.

How to integrate and manage built environment information and data is also one of the main goals from Design informatics studio, this research tries to communicate between several software and pass data from one to the other, and together makes the final program user-friendly. Indoor comfort, especially daylight comfort is very close to our daily life, our health, efficiency and mental state. This research takes the architecture faculty building on campus and its surrounding environment as a case study, to see the impact of changing of surrounding and building component, and provide designers suggestions about urban planning and building renovation.

2. What is the relevance of your graduation work in the larger social, professional and scientific framework.

Architecture modeling software Rhino and BIM tools represented by Revit are commonly used by architects, they have their own advantages in modeling refinement, running simulation, and digital management, etc. However, these tools operate independently, following distinct modeling principles. Furthermore, they are primarily designed for the architectural scale, which introduces challenges when integrating them with city and environmental models. But from the point of view of daylight study, the surrounding environment is often an important factor influencing the indoor daylighting performance of buildings.

Moreover, complex grasshopper scripts and extensive simulations can pose challenges when it comes to seamlessly sharing workflows among teams. This complexity further hinders collaboration between architects and urban designers, as well as communication with governments and policymakers.

This research is aimed at developing a tool and workflow that leverages the strengths of both Revit and Rhino, incorporating the building's surroundings information. The envisioned solution involves a user-friendly interface, operating on a room-by-room basis with a simple point-and-click system. This approach empowers users to swiftly make adjustments to building elements and surroundings. And could be supported by a server capable of efficiently computing and displaying simulation results. Reduce barriers for designers, making it possible to quickly visualize the impact of changes in indoor and outdoor factors on indoor lighting in completed buildings, so that quick measures can be taken to improve it,

and the impact on existing buildings can be avoided during outdoor planning. This will contribute to maintaining and improving daylighting in public spaces.