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Utilization of Big Data for Digital Architecture-based Site Analysis with Site Studies in Badung Regency - Bali

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ABSTRACT
The Industrial Revolution 4.0, which led to the evolution of social media, digital messaging services, online meetings, and lectures, has become a part of human life, specifically after the Covid-19 pandemic. However, this phenomenon increases information circulation, and traffic, which accumulates into large or Big Data. This research aims to examine the use of geospatial information as primary data in conducting site analysis. This experimental research was conducted on the Ngurah Rai bypass road close to the Dewa Ruci Monument. Spatial data, such as vehicle paths, and surrounding tread boundaries, were produced from data stored in google earth, OpenStreetMap, and one climate as well as sorted by Rhinoceros, Grasshopper, and Elk software. Ladybug software was also used to produce climate data, such as shadow areas and solar radiation. Finally, a simple building composition optimized with Galapagos software in a series of simultaneous processes utilized these data. The result showed that geospatial data help students make site analyses and produce more accurate proposals.

Keywords: *The industrial revolution 4.0, Big data, Site analysis, Rhinoceros, Grasshopper, Elk, Ladybug.*

1. INTRODUCTION

Simulation technology has become part of architectural learning professionally used to support complex design processes due to its rapid development. Products manufactured using this technology are relatively accurate and widely utilized. The simulation process requires various initial data on climate conditions, the surrounding building environment, vehicle circulation, etc. However, due to the advancement of information technology and the internet, which culminates in Big Data, accessing the right information becomes generally difficult. Therefore, it is important to utilize commercial and non-commercial applications to support the use of Big Data for simulation needs in architecture. An example is the OpenStreetMap (OSM), an open-source geographic platform that allows users to utilize the provided spatial data and make contributions through self-surveys, GPS devices, aerial photography, and other free resources. The app followed the success of Wikipedia and has provided spatial data from 1.6 million contributors. Spatial Data is generated under the Open Database license, while the site is a sub-category of the OpenStreetMap Foundation, a non-profit organization based in the UK. The larger the data collected, the more significant the data available, and the more varied the scope. Therefore, this research aims to determine the strategies architects use to analyze existing data for the digital architectural design process, specifically at the site stage. This is because architects are still working on this process intuitively and have not used accurate data to determine cardinal directions on the site, the sun's movement, etc. Furthermore, through existing data, they can create design objects capable of adapting to the parameters created. The Grasshopper, Elk, Ladybug, and Climate Studio software were used to determine the location analysis modeling method through a parametric approach. This research was carried out in the Badung area on Bali Island.

2. RESEARCH OBJECTIVES AND URGENCY

One of the advantages of using a parametric approach is that when change occurs on a design

parameter, it affects others simultaneously and according to the algorithm entered as input data. This tends to affect the architectural learning model. Furthermore, using this parametric simulation method leads to significant changes, such as the ability to test various dimensional parameters of material quality simultaneously. Others include performing analysis and simulation tests several times in one semester of learning, conducting comparisons with analysis using the same building material to determine the differences in values. The specific purpose of this research is to produce digital architecture learning modules with accurate and efficient performance in the use of practice time, improve students' analytical and creative skills, and take full advantage of Big Data.

3. LITERATURE REVIEW

Students are expected to understand the measurable parameters of building design from the city scale to the site's environment, such as requirements, climate, principles of light, and measurable solar heat in the design process through digital architecture learning. Therefore, understanding the process will provide a method capable of producing the same results for every student. This is intended to promote and equalize understanding of the material provided, thereby making the learning process effective and efficient within the allotted time in each semester.

3.1. Information Technology and City Data for Architectural Needs

Advancement in information technology has changed peoples' way of socializing and living [1]. Preliminary research analyzed the numerous new opportunities offered by technology, such as creating a new reality where the environment and digital media are integrated into daily life [2]. Students and the New Generation of Architectural Practitioners are the Digital Natives [3] familiar with digital technology. However, the use of this technology is still limited to applications supporting the work of architects such as CAD (Computer-Aided Design) and BIM (Building Information Modeling). Presently, the use of software technology is only limited to visualization, with the advancement of Virtual and Augmented Reality and Geo-Reference technology [4].

3.2. Building Modeling Simulation in Architecture

Simulations in architecture are generally divided into 3 types, namely figures, photography, and building models. However, this research focuses on simulation through building models with various types obtained through parameters calculation. The building model can be tested using physical or virtual techniques to calculate the sunlight and wind movement. For example, the Wind Tunnel is used to test the wind movement against the building, while the BESTEST (Building Energy Simulation Test) calculates the amount of energy consumption for optimization. Software, such as "Design Builders" and "Ecotect Software Analysis," is used to simplify the process of identifying various variables in building models, namely DBT (Dry Bulb Temperature) and WBT (Wet Bulb Temperature). The designer can change the parameters during the research process, check the modeling results and select the various probabilities offered. Therefore, the results can be directly applied to the building design.

3.3. Parametric-based Digital Architecture

The parametric approach in digital architecture produces various design solutions through a visual scripting approach. Parametric modeling requires various parameters, such as initial formation, numerical variables, and operational relationships packaged into visual formulas to produce solutions and methods [5] This research analyzed a building performance design simulation process using a parametric approach with Rhinoceros and Grasshopper software, which led to a diverse and optimal design solution.

3.4. Site Analysis

The site analysis stage is the initial design cycle based on physical properties. It is used to get a clear picture of a site's condition for architects to provide appropriate and adaptive design recommendations [6].

3.5. OpenStreetMap (OSM)

OSM is a large geographic information service crowdfunding project established in 2004. It aims to provide geographic information that everyone can utilize through crowdfunding. Furthermore, it is a database distributed software developed through the Open Database License (ODbL). It provides an opportunity for contributors to provide information freely accessible to others [7].

3.6. Parametric Approach

The parametric approach in digital architecture produces various design solutions through visual scripting [8]. Parametric modeling requires various parameters, such as initial formation, numerical variables, and operational relationships, packaged into visual formulas to produce various solutions [5]. This research was carried out using a building performance design simulation process, which led to a diverse and optimal solution.

4. RESEARCH METHODS AND STAGES

This research was conducted using the quasi-experimental methods with modeling strategies and simulation processes that utilize Rhino-Grasshopper, Elk, and climate studio software. The process starts by determining the tread position taken through the Openstreetmap application. Fig. 1 shows a map of the Badung-Bali area.

Figure 1 Site location to be analyzed.

Source: Research Documentation.

Once the location is mapped, it is exported with the OSM extension containing XML-based information, such as nodes, connections, and relations. This information is then sorted and translated to determine the roads, land boundaries, and building mass formations, using the Elk and Grasshopper applications. Elk generates nodes that can be connected with polylines to produce the needed information (see figure 2).

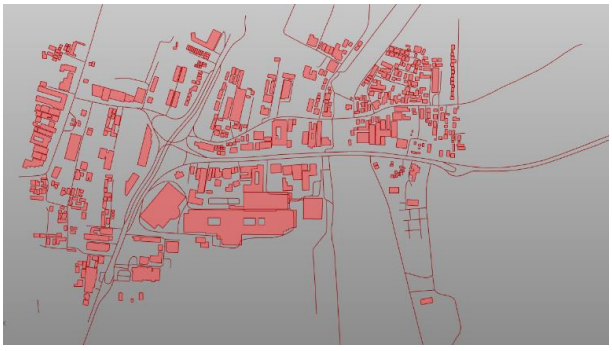

Figure 2 Site location to be analyzed.

Source: Research Documentation.

The OSM conversion results are used as initial data in conducting simulations and building site analysis. The following step is to enter climate data obtained from https://climate.onebuilding.org/, which is managed and presented through the climate studio application operated on the Grasshopper application. Therefore, students do not need to carry out the import-export process from different software. Figs. 3 and 4 show an analysis of the sun and wind movement at the site.

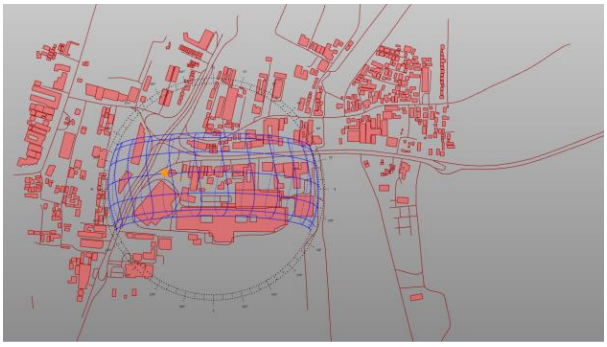

Figure 3 Sun hour analysis on the climate studio app.

Source: Research Documentation.

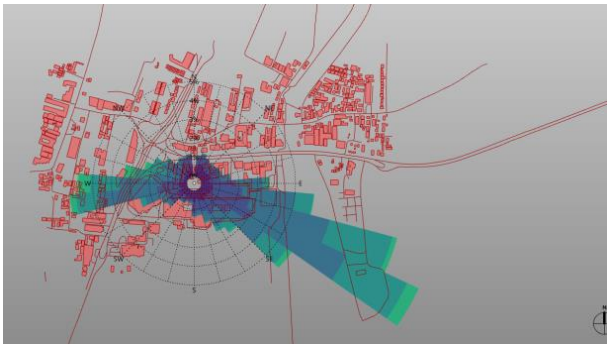

Figure 4 Sun hour analysis on the climate studio app.

Source: Research Documentation.

These processes are created concurrently in a visual script compiled in the main Grasshopper application, which allows students to define analytical parameters for an object, such as wind speed and direction at a site. Through the windrose diagram, students are able to determine the wind speed and direction in the Badung area of Bali. Fig. 5 shows a visual script created to analyze a site.

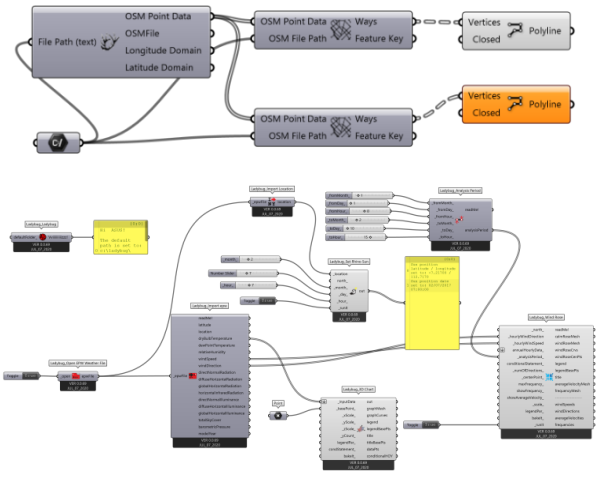

Figure 5 Visual script on grasshopper application.

Source: Research Documentation.

This series of processes show that the average wind speed in the Badung-Bali area is 8-10 m/s with the dominant direction of east-west movement. From January to October and October to December, the largest wind directions are from the East and West. The highest temperature throughout the year is 30-32 degrees Celsius, however, this is strongly influenced by increasingly extreme global climatic conditions. In this process, the shadow movement on the building is also displayed for students to see the shaded areas. This process shows real data in the field, which indicates the proposed design response is more accurate.

5. CONCLUSION

Based on the activities that have been carried out, the workflow that occurs can be arranged as follows Figure 6:

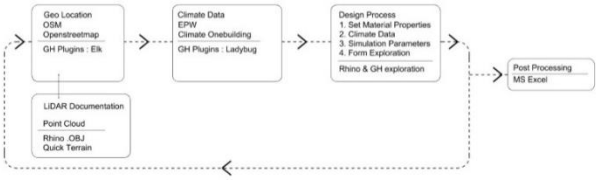

Figure 6 Workflows that are structured using a parametric approach.

Source: Research Documentation.

Therefore, through this research activity, the geographic and climate data are processed and directly visualized in the form of site conditions, diagrams, or dynamic building simulations using the Rhinoceros software. This shows that numerous factors affect tall buildings, such as their orientation, which affects the amount of sunlight. This amount should be attributed to the number of openings in the building. Hence, numerous factors need to be considered at the design stage, which requires a location analysis process with accurate data. The parametric approach can accommodate a dynamic design process, hence, the simulation of environmental impact analysis at the site is integrated with the process. The designer's understanding and experience of external environmental data greatly influence the success of this process. Therefore, this is not recommended for use by entry-level students. From a software usage point of view, a fairly good understanding of parametric-based workflows is needed due to the demands to understand data behavior in visual scripts such as translating environmental parameters into data sets lists. In practice, the process of reading external input data such as OSM and EPW takes a long time when carried out simultaneously, therefore, users need to separate certain parts to avoid crashes. Accordingly, it can be concluded that architects can take advantage of Big Data circulating in cyberspace using the parametric approach because it opens up new opportunities for designers and students to streamline and integrate the initial design process with site analysis. However, this process requires knowledge of environmental stimulation, sufficient experience in operating the software parametrically, and the complexity which strongly influenced by the capabilities of the user and the device.

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