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A Visual Cross-software Evaluation Platform for Preservation and Revitalization of Historical Villages: Application in Qinchuan Historical Village, Zhejiang Province

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The preservation and revitalization of historical villages have emerged as prominent topics within the realm of Chinese cultural heritage preservation. However, persistent challenges arise from the lack of spatial digital information and the complexities involved in sampling and analyzing these historical sites. An emerging field of inquiry addresses the effective analysis of the spatial elements of historical villages for design evaluation and research in the context of their preservation and revitalization, with the objective of aligning them with contemporary needs. This research integrates Unmanned Aerial Vehicle (UAV) 3D oblique imagery and Computer Vision (CV) techniques to replace traditional data collection methods, thereby addressing challenges caused by insufficient data and providing a more economical and efficient solution. Furthermore, it establishes a linkage between Rhinoceros-Grasshopper (GH)-Unity 3D to create a novel cross-software evaluation platform. This platform assists designers in researching and analyzing the spatial aspects of historical villages and various streetview elements, including building, sky, ground, tree, door, window, water, plants, person, and transport, thereby facilitating the assessment of their impact on the preservation and revitalization of traditional historical village.

Keywords: *computer vision, parametric design, villages protection and renewal, oblique imagery, cross-software*

Introduction

The safeguarding and transmission of tangible and intangible aspects within traditional villages, the improvement of living conditions in these areas, and the maintenance of the spatial layout characteristic of traditional villages have become focal points in the field of traditional village preservation. Currently, conventional approaches for analyzing and appraising historical villages often rely on labor-intensive data collection processes, typically involving on-site investigations or photographic assessments. These methods are expensive and suffer from the loss of historical documents, lack of data information, and sampling difficulties due to geographical or topographical factors. Consequently, the current pivotal issue lies in exploring how to leverage and integrate advanced computer technology to promote the revitalization of historical villages more scientifically and efficiently, in contrast to traditional and less accurate analysis and evaluation methods.

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This research examines the potential of Computer Vision (CV) technology for driving automatic parameter analysis to generate street view facade designs through parameterization. The computer-aided design software employs 3D technology to develop visual design tools and introduces two key innovations. Firstly, it seeks to employ CV technology to segment and identify images or point clouds associated with existing building structures and environments. This method combines the strengths of CV technology with parametric design methods to identify 10 elements (building, sky, ground, tree, door, window, water, plants, person, and transport) in historical villages and traditional villages undergoing revival under heritage protection. Secondly, the research employs the game development software Unity to create a cross-software evaluation plug-in, with the aim of enhancing efficiency for professionals in the industry. The viability of this technology will be rigorously evaluated in Qinchuan, a representative traditional Chinese village.

Literature Review

Key Factors in Historical Village Preservation and Revitalization

The preservation and revitalization of historical villages require a comprehensive approach that considers various design scales. At the general plan scale, factors such as geographical environment, climate conditions, and hydrological conditions play a crucial role in the preservation and revitalization of historical villages. The geographical environment, including mountains, plains, or valleys, influences the village layout and architectural style (Smith 2015). Different climatic conditions require specific architectural forms and material choices, which impact the overall impression of a historical village. The management of water sources also influences the design of main thoroughfares within the village (Jones & Brown 2018).

At the settlement scale, the analysis of architectural aggregations, residential clusters, functional zoning, and the layout of religious buildings is essential. To gain an understanding of the composition of architectural clusters and the overall planning of the village, including the arrangement of residential areas and public spaces, it is crucial to consider the arrangement of residences, such as courtyard-style or row-style. The arrangement of residences reflects the village's social and cultural characteristics. The division of a village into distinct areas for living, working, and public activities helps to maintain a harmonious and functional environment (Johnson 2017, Yang et al. 2020, Jaszczak 2017). The layout and influence of religious buildings and ancestral halls also contribute significantly to the village's character.

At the individual building scale, characteristics such as building types, facades, materials, and structures are considered. The village's historical and functional diversity is reflected in its diverse range of building types, including residential, commercial, warehouse, and public buildings (Gonzalez 2016). Elements such as doors, windows, and roofs significantly influence the village's

aesthetic and architectural style. The use of materials such as wood, stone, and brick affects the village's color palette and visual appeal. In addition, structural forms such as beam-column structures and brick-and-stone structures contribute to the village's architectural integrity. Finally, the temporal hierarchy, including historical evolution, significant events, and building renewal, must be considered. Understanding the village's establishment and development process is crucial (Korten 1980, Li et al. 2019). Historical events such as wars and natural disasters can have a significant impact on the village's architecture. The renovation, expansion, and reconstruction of buildings during different historical periods contribute to the dynamic changes in the village's architectural and streetscape (Li et al. 2019). Therefore, it is essential to record the current architectural features of historical villages accurately and efficiently, and to establish a data library for this purpose.

The Role of Designers in Traditional Village Preservation and Revitalization

Designers play a pivotal role in preserving and revitalizing traditional villages, contributing their expertise in various stages of the process. The complexities involved in balancing cultural preservation with modernization, and the absence of standardized methods for assessing the historical significance of sites can make decision-making challenging for designers (Smith 2018). Despite the existence of evaluation standards or rating systems like the Leadership in Energy and Environmental Design (LEED), the decision-making process for designers remains complex. Efforts to preserve and revitalize historic villages encompass architectural and environmental considerations, cultural heritage, community needs, and economic feasibility. Designers must develop strategies that respect historical and cultural heritage while addressing local realities and future development needs (Gong & Li 2020, Sanchez & Wang 2019). Designers must rely on their experience, intuition, and collaboration with local communities in such contexts to make informed decisions.

Digital Technology Applied in Historical Village Design

The preservation and revitalization of traditional villages have become focal points in cultural heritage preservation, with the aim of improving living conditions while maintaining the characteristic spatial layout of these settlements. Conventional approaches to analyzing historical villages often rely on labor-intensive data collection processes, such as on-site investigations or photographic assessments. However, these methods are costly and often hindered by challenges such as the loss of historical documents, lack of data information, and sampling difficulties due to geographical or topographical factors.

In light of these challenges, growing research has investigated leveraging advanced computer technology to preserve and revitalize historical villages. Digital technologies (Xiao et al. 2018, Sestras et al. 2020) such as mapping, imagery analysis, and 3D modeling have been introduced to preserve and revitalize historic villages for data collection, visualization, analysis, and assessment. For

instance, 3D modeling has been used by Yu et al. (2019) to recreate historical village structures, allowing for detailed virtual tours and aiding in restoration efforts. Similarly, Li et al. (2021) employed imagery technologies to monitor and assess the condition of historical buildings, facilitating proactive maintenance and conservation strategies. By mapping the landscapes and incorporating oblique imagery, Pratt and Heyes (2022) can more effectively comprehend the historical significance of these sites and work toward their preservation. (Zhang et al. 2022) utilized oblique imagery and mapping technologies to effectively encapsulate the traditional settlements and villages' essences to enhance the understanding of traditional villages and revitalize them.

Additionally, parametric design tools have been used for generating complex architectural forms and optimizing design alterations in revitalizing traditional villages. The parametric planning and design method is more creative than the traditional manual planning and design method. It is easier to create a form that contains a rigorous logic of its spatial organization, which is the most essential and core feature of the current traditional village space (Jiang et al. 2023). Parametric design tools not only enhance design efficiency but also bolster precision and adaptability, thereby better addressing the myriad challenges historicak villages encounter in the processes of preservation and revitalization.

In recent decades, Machine Learning (ML) and Artificial Intelligent (AI) have been applied to architecture design, construction, and operation. Among the most prevalent technologies applied to in architecture include natural language processing, computer vision (CV), and neural networks (Sanchez 2023). However, there is comparatively less applications in building planning, especially in rural settings (Hastak and Koo 2017). Due to the pivotal role of visual data, CV assumes particular importance in the planning and design process (Liang et al. 2023), especially in swiftly acquiring the relevant parameters of existing buildings and urban areas. To harness the efficiency advantages of Machine Learning (ML), Artificial Intelligence (AI), and neural networks, computer vision (CV) technology can be applied to various aspects of research and design within historical villages. By leveraging ML, AI, and neural networks, CV can streamline data acquisition processes, aid in the analysis of historical village layouts and streetscapes, and facilitate architectural surveys. This integration enables the automated extraction of relevant information from large datasets, allowing for more accurate and comprehensive assessments of historical contexts. Furthermore, these technologies empower designers by providing valuable insights and supporting informed decision-making throughout the planning and design phases of historical village preservation and revitalization projects.

Despite significant advancements in digital technologies and their applications in heritage conservation, several gaps remain in the effective preservation and revitalization of historical villages. One major gap is the lack of integrated platforms that combine multiple advanced technologies for comprehensive analysis and design. Current methodologies often involve labor-intensive and fragmented approaches that do not fully leverage the potential of emerging technologies like UAV 3D oblique imagery and computer vision (CV). This research addresses these gaps by proposing a novel cross-software evaluation plug-in that integrates

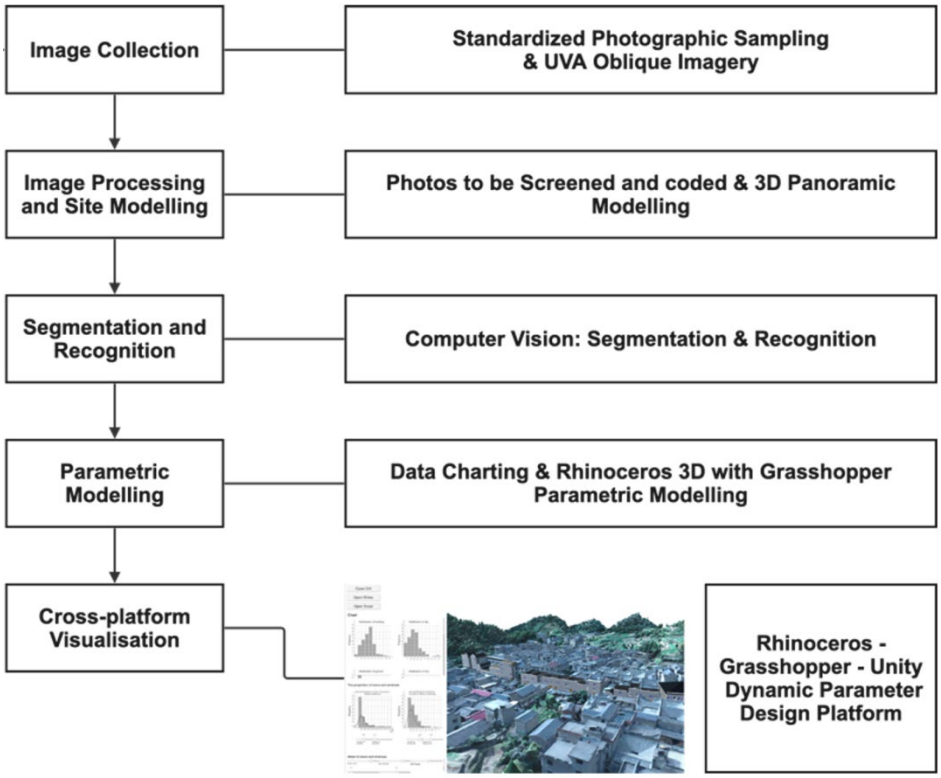
Excel, Rhinoceros-Grasshopper (GH) and Unity 3D. This platform facilitates the parametric analysis, editing and visualization of spatial elements in historical villages, offering a more efficient and economical solution for data collection and design evaluation. The application of this platform in Qinchuan Historical Village, Zhejiang Province, demonstrates its potential to enhance the preservation and revitalization efforts by providing a dynamic and interactive tool for designers and researchers.

Methodology

The Qinchuan historical village in Zhejiang Province, China, is the site of the field study to demonstrate the method/technologies proposed in the study. All data and images were gathered from this location, and the cross-software evaluation plug-in will be illustrated using Qinchuan as a case study.

A five-step process is employed to outline the construction of a cross-software evaluation plug-in for the revitalization of historical villages. These steps include image collection, data processing, segmentation and recognition, parametric modeling, and visualization (see Figure 1).

Figure 1. *The Five-Step Methodology for Creating Cross-Software Evaluation Plug-in*



Source: Made by author.

The data and image materials were collected with great care by our research team. Upon completion of the oblique image, the 3D model is generated using the open-source software GET3D Cluster (GC). The use of CV technology allows for the segmentation and recognition of 10 streetview elements within the image. From there, the figure-occupancy data for each element is determined and a graph of its normal distribution is generated. Subsequently, the 3D model is linked with the parametric design software Grasshopper (GH), which enables parametric adjustments to the proportions of streetview elements in the facade. This ultimately generates a new design. All parameter tuning is conducted via a developed cross-software evaluation plug-in tool.

Image Collection

The initial step in acquiring information about the historical village is the collection of images. A standardized sampling methodology employing oblique imagery is utilized for the photographic documentation.

- Standardized sampling

  Along the main road of the historical village, which measures 980 meters in length, our team captured standardized photographic samples of streetview elements. The camera was positioned on the central axis of the main road, with images captured at 10-meter intervals. Each group of images included both forward and backward perspectives.

  For this process, a Canon 60D camera and SIGMA ZOOM 18-200mm 1:3.5-6.3 II lens were employed, maintaining a camera height of 170 cm ± 2.5 cm and a horizontal angle to the ground of ± 5 degrees. The focal length employed was within the range of human eyes, equivalent to a lens of 18mm, which is equivalent to a focal length of 28.8mm.

  The standardized photography was conducted over two days, from 2:00 p.m. to 4:00 p.m. each day, resulting in the capture of 194 images. The image data obtained from this standardized photography will be integrated into the historical village dataset, serving as the basis for segmentation and recognition and subsequently acting as references for parametric design.

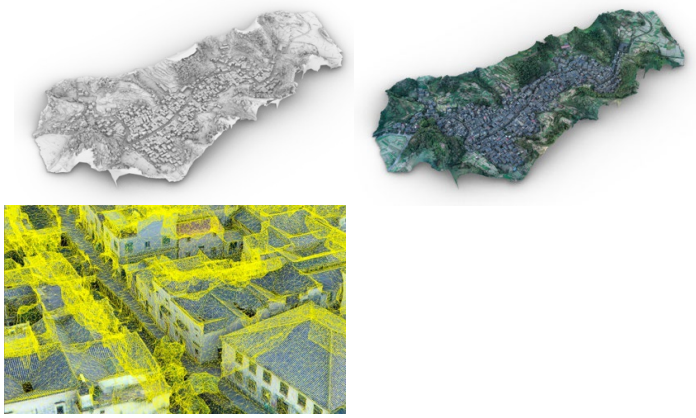
- Oblique imagery

  Oblique Imagery employs DJI-Terra for shooting. Initially, the village was. manually demarcated based on Google Maps, and five flight paths were created in the format of path files (kml). These paths were then imported into the UAV equipment, resulting in the capture of 2192 photos. All images are utilized to create a dataset, facilitating the generation of 3D models for historical villages. Firstly, the flight range and geographic location information of the UAV must be determined through Google Maps, and a KML geographic location information file must be generated.

  Secondly, the KML geographic location information file must be imported into the DJI Phantom 4 RTK mission manager, the appropriate flight altitude and mission settings must be debugged, and the flight path

information for 5-direction tilt-shot photography must be generated.
Thirdly, the flight path and photography parameter information is uploaded to the drone, the appropriate take-off and landing sites for the UAV are identified, and the flight photography mission is initiated.
Once the mission has been completed, the data generated by the tilt-shot photography will be processed. This data will be uploaded to an open-source software, GET3Dcluster, which is designed to combine the mission KML file with the image database.
The data will then be encoded and sorted automatically into a cloud file, which will generate a 3D spatial point cloud based on the image information. This will then be converted into a spatial mesh file through the use of cloud computing, which will automatically generate the mesh file with material and color information. The 3D spatial information of historical villages can be generated with material and color information, which can then be edited using a mesh file or Objective file.

Figure 2. *3D Spatial Information - Spatial Material and Color Information - Editable Mesh Grid*



Source: Made by author.

Image Processing and Site Modeling

The combination of the aforementioned two shooting methods results in the creation of the historical village dataset, in which the collected image data and data jointly contribute to its formation. The initial processing of the dataset involves a cleaning procedure, during which the images captured through standardized sampling are manually screened to remove any images that have been overexposed or out of focus. Subsequently, the images are encoded. The photos captured through standardized sampling are manually encoded, whereas those taken through oblique imagery undergo automatic encoding during the shooting process.

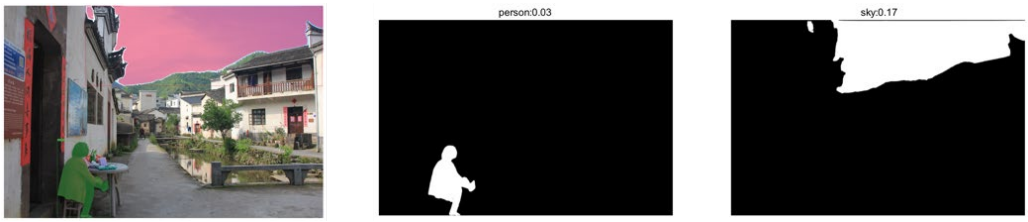
The images captured along the five flight paths are imported into the open-source software GET3DCluster, utilizing cloud-based automatic modeling software in accordance with the coding order. This process generates a private cloud project that, upon cloud processing, automatically produces a 3D historical village panoramic model along with associated materials based on the input pictures.

Segmentation and Recognition

Semantic segmentation and recognition are both essential scenarios of CV applications (Chai et al. 2021). DINO (Liu et al. 2023) classifies all elements into ten categories-building, sky, ground, tree, door, window, water, plants, person, and transportation-by object detection in a preconfigured scale and ratio calculation. Semantic-SAM (Li et al. 2023) is used to segment photographs taken under harmonized standards into elements. The integration of models enables automatic image processing and analysis, allowing batch processing of image files, identification and segmentation of different objects within the images, and recording the pixel ratio for each category. The specific workflow is as follows:

First, set the environment and path to get the working directory for the 194 photos. Set the path for the GroundingDINO and SAM model weight files and check for their existence. After importing the necessary libraries and modules and determining the device type, load the GroundingDINO and SAM models. After traversing the data directory, identification and segmentation are performed for each file. The process begins by reading a single image file, using the GroundingDINO model to detect a specific streetview element in the image, annotating the detected object, and drawing bounding boxes and labels. The SAM model is then used to segment the detected target and create a mask. At the same time, the segmentation results and category labels are applied to the original image. Further data analysis is then performed by calculating the pixel proportion of each segmentation mask, generating a proportion list for each category, and summarizing the proportion of all categories for each image (see Figure 2). To ensure the accuracy of recognition, a cyclic processing concept is introduced. This entails recognizing, segmenting, processing, and summarizing each element in the 194 image files in the directory. Finally, the pixel ratio data for the ten streetview elements in each image file is obtained.

Figure 2. *Semantic Segmentation and recognition of Element and its Ratio for Each Category*



Source: Made by author.

Parametric Modeling

Grasshopper (GH), a parametric design plug-in of Rhinoceros, is used for parametric adjustment to design the renovation of historical village buildings (see Figure 3).

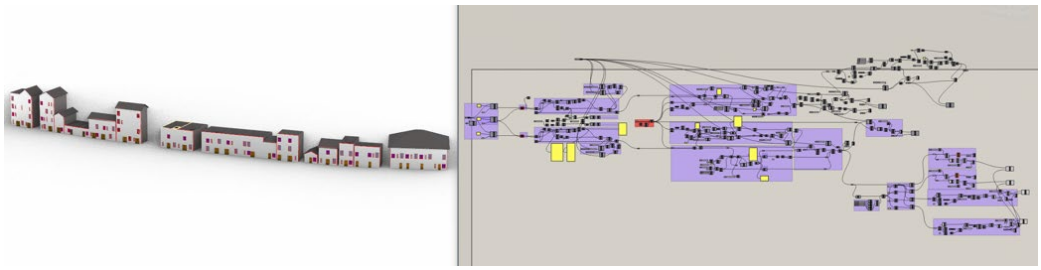
Excel data is imported into GH, and the proportion data for doors and windows, S-door/S-wall total, and S-window/S-wall total for Qinchuan Historical

Village are extracted. The proportion data for doors and windows are then organized by size, and the maximum and minimum values for each group interval are determined. Equal partitions corresponding to the number of facades are created, with the proportion of doors and windows associated with each interval. The number of data within each interval is calculated. The median value of each interval is selected and replicated a certain number of times, resulting in 194 data groups consisting of 27 different data points.

Select the facade contour using a curve and arrange it from left to right. After obtaining the door width by dividing the door/façade area of the buildings along the street and applying the door height module, it is aligned with a fixed module to ensure that it adheres to standard door width sizes. The positioning points for the doors are determined by dividing the bottom edge of the facade and randomly selecting a specific point to place the door.

The facade contour line is selected using a curve to assess the facade height and determine if the window is multi-layered. Different layer heights are set at intervals, each with its own layer height line. The iso-layer height lines determine the window positions and are constrained within the facade. By using random height times random width, multiple sets of window sizes are derived. The number of windows inside is determined by checking that the sequentially added area remains within the window ratio. Consequently, window contours of random size are generated and extended at points along the floor height line.

Figure 3. *GH as a Parametric Design Plug-in of Rhinoceros*



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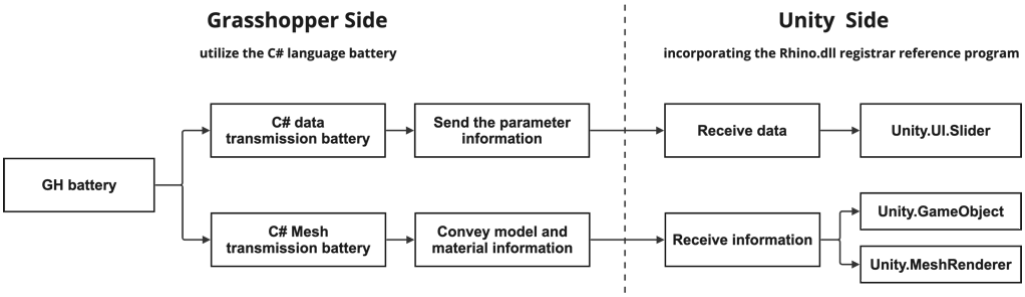
The Cross-Software Evaluation Plug-in

The objective of the cross-software evaluation plug-in is to facilitate visualisation. The software was developed using Unity, a game development software known for its robust code compatibility (see Figure 4). Both Unity and GH employ the C# programming language. To facilitate communication between the two, the Rhino.dll registrar reference program can be incorporated into Unity as a port. Two digital batteries facilitate the transmission of GH data, with the C# Mesh data transmission battery conveying model and material information. Upon receipt of the information, the Unity terminal creates a Unity.GameObject instance, which simultaneously synchronizes the model information and the Unity.MeshRenderer and renders the materials. Once the C# data transmission battery has transmitted the requisite parameter information to the Unity end, a Unity.UI.Slider instance is generated in order to synchronize the parameter

information. The cross-software evaluation plug-in interface displays a three-dimensional model of the street and graphics representing ten elements. The interface permits the user to adjust parameters such as the proportion of doors and windows. Consequently, the 3D model of the street is updated in real-time in accordance with the specified parameters, facilitating the rapid generation of revised design schemes.

Figure 4. *GH Conveys Data and Information to Unity*



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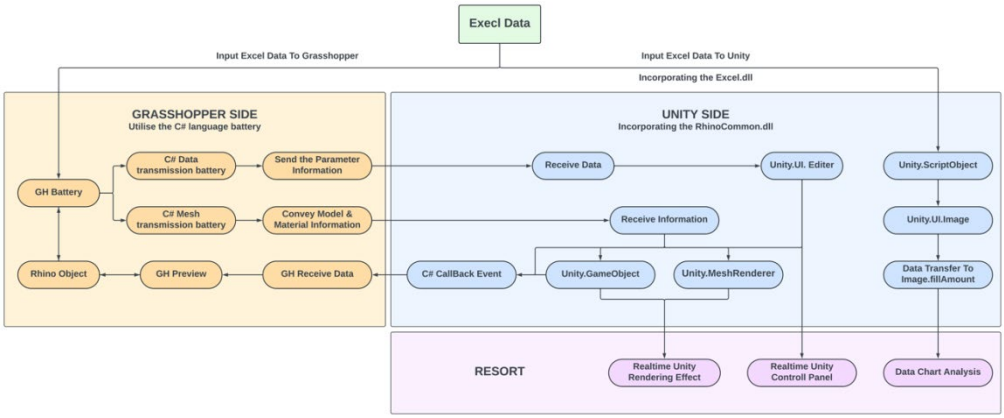
Results

The cross-software evaluation plug-in is a *Data-Rhinoceros&GH-Unity* interactive visualization interface. Using the button assist, all the data of the streetview elements in the Excel file are imported into GH and Unity to obtain the parametric facades, diagrams, and rendered 3D model. By dragging the sliders, the dashboard presents the visualized design results in real time (see Figure 5).

Figure 5. *The Framework of Data-Rhinoceros&GH-Unity Evaluation Plug-in*



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Automatic Data Capture and Data Chart Presentation

The data in Excel is subjected to CV segmentation, representing the area ratio of the 10 streetview elements obtained after recognition in the photo. Through coding, we incorporate the Excel.dll library file into Unity as a reference, enabling

Unity to automatically extract horizontal and vertical coordinate data from Excel. This process facilitates the construction of the dataset for Qinchuan Historical Village. The entire dataset is stored in Unity's newly created ScriptableGameObject, which serves as a reference for rendering the data graph.

The data chart is intended to further visualize the data automatically captured in the dataset, focusing primarily on the normal distribution of the 10 streetview elements. Through coding, the maximum value is determined, the horizontal axis is synchronized, and the frequency of data falling within the range is counted. The segmented data is then filled using the Image component in Unity to achieve the visualization of a dynamic data chart.

This allows designers to consider and analyze various environmental and architectural factors in a convenient manner, as well as to gain an intuitive understanding of the statistical and analytical aspects of the street scene. Synchronization enhances the designer's comprehension of the current state of the building, providing guidance for subsequent designs through data charts.

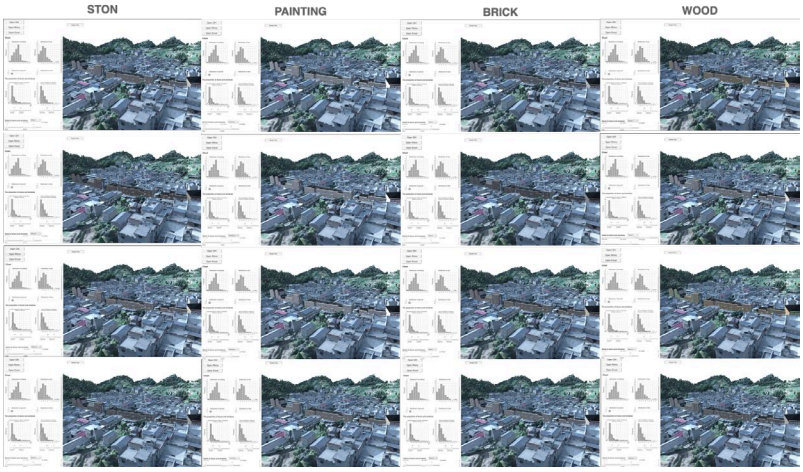
Fine-tune the Proportion Parameters for Streetview Elements in the Design

In Unity, the first step is to create a grid and a general material. It then calls the grid and material from the GH data structure datatree, creating a new list to store the data. This data is synchronized with the new Rhino Runtime event, and the color and transparency information of the material and model is transferred using the GH C# Mesh data transfer component. Unity receives the mesh information using the GeString method and creates a Unity.GameObject instance to generate a 3D facade model. At the same time, material rendering information is passed from GH to Unity via the C# Mesh component, resulting in the creation of a Unity.MeshRenderer instance that represents the facade rendering effect.

The Unity side receives information from the slider and generates a Unity.UI.Slider instance, allowing users to adjust parameters by dragging the slider left and right. When the normal distribution plot is within the threshold range, users can not only adjust the proportions of doors and windows to buildings separately, but also fine-tune details such as windowsill height, window thickness, and door frame thickness. By adjusting the Random Seed value, users can achieve a randomized distribution of doors and windows.

Given the significant impact of building materials and colors on the preservation and revitalization process, the Unity.UI interface includes a material selection menu. This feature allows users to replace materials on street facades and to select and edit different colors for the same material, further optimizing the streetview facade design (see Figure 6).

Figure 6. *User Interface (UI) for Cross-Software Evaluation and Editing of Façade: Streetview Elements*

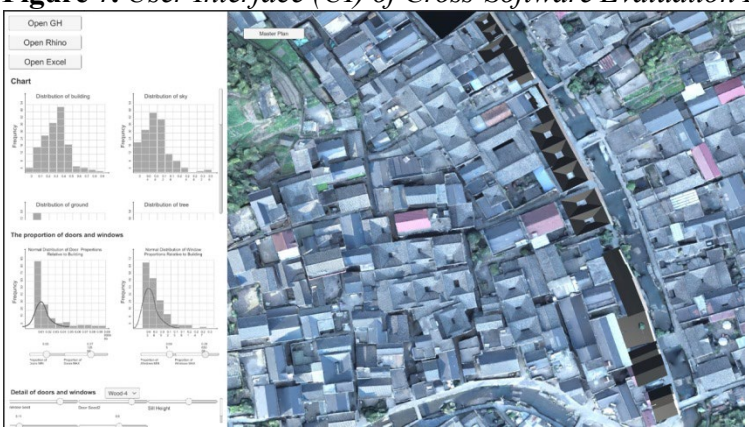


Source: Made by author.

Dynamic 3D Model Rendering

In Unity, the initial step involves the establishment of a grid and the general material. This is then called from the GH data structure datatree, creating a new list to store the data. This data is synchronized with the new Rhino Runtime Event, and the color and transparency information of the material and model is transmitted through the GH C# Mesh data transmission component. Unity receives the mesh information using the GeString method and creates a Unity.GameObject instance, generating a 3D facade model. Simultaneously, material rendering information is transmitted from GH to Unity through the C# Mesh component, resulting in the generation of a Unity.MeshRenderer instance, representing the facade rendering effect. The interface includes a "Master Plan" button, which generates real-time rendered images of the desired design area from an overhead perspective. It provides an overhead view of the buildings within the design area, including the site environment, settlement relationships, hydrological conditions, and vegetation (see Figure 7).

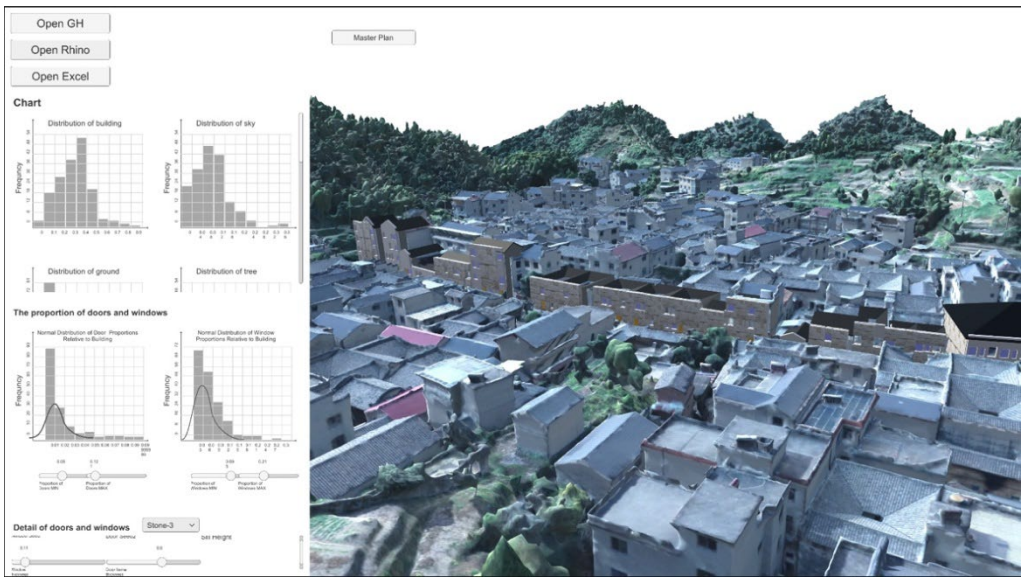
Figure 7. *User Interface (UI) of Cross-Software Evaluation Plug-in*



Source: Made by author.

The Unity.UI interface allows users to control the real-time 3D rendering interface using the mouse and scroll wheel. This enables the generation of real-time 3D rendered models from any desired angle based on user requirements (see Figure 8).

Figure 8. *User Interface (UI) of Cross-Software Evaluation Plug-in*



Source: Made by author.

The 3D model undergoes dynamic changes in response to adjustments to certain parameters, and the results of these adjustments can be observed in an intuitive manner. The integration of real-time data changes into the design workflow allows for instantaneous model updates, significantly enhancing design efficiency.

Discussion

Using the method described in Section 2, we developed a dataset for the historical city of Qinchuan, including streetview elements along the main road and 3D model data for the entire city. Using CV technology, the main roads were segmented and identified based on the 10 streetview elements, and the proportions of these elements were further analyzed. Systematic data collection and data chart analysis for the street scene elements of historical villages can help design staff provide clearer insights and analytical data for the influencing factors of Streetview. Within the threshold range, the proportions of doors, windows and buildings are parameterized and adjusted according to the normal distribution chart, effectively facilitating the renewal and design of street facades for historical buildings. As a cross-software evaluation plug-in breaks down the barriers between software and enables cross-software collaborative design, thereby increasing design efficiency.

However, this experiment identified some potential subtle limitations, mainly

concentrated in the early stages of image collection. The photos were not taken during all four seasons, and trees may block houses in summer, a challenge that can be better addressed in future experiments. The transformation of a small number of houses has slightly compromised the unity of opposites and heights. In the future, more accurate and faster streetview data and base parameters can be achieved through advanced and efficient streetview data collection tools and technologies. Targeted CV training in old village streetscapes can further improve recognition accuracy.

This study revealed several shortcomings and limitations in our existing data collection methods, namely standardized photography and drone oblique imagery. Issues such as blind spots, object occlusion, and shadows were identified. Additionally, there are limitations in the comprehensiveness of the data, as it lacks interior spatial information of individual buildings and high-resolution scans of specific historical features. Therefore, to upgrade our spatial 3D database in the future and make the plug-in more systematic, efficient, and precise, it is necessary to integrate more professional, accurate, and efficient technical measures.

Conclusion

The preservation and revitalization of historical villages is a complex undertaking that involves numerous factors, including historical context, cultural heritage, local characteristics, and cultural heritage protection. This makes it a challenging and lengthy endeavor. Consequently, the integration and development of new design tools that utilize CAAD and AI technologies become crucial. Currently, the methodologies employed for updating historical villages are relatively antiquated, and the majority of existing technologies are disparate, lacking cohesion and exhibiting low design efficiency.

This paper outlines the development process of the cross-software evaluation plug-in, which efficiently imports analysis data of street view elements through CV at the initial stage. This establishes cross-software linkage, connecting an Excel database to Rhinoceros-GH-Unity. The cross-software evaluation plug-in employs a parametric dynamic adjustment process through user interface (UI) functionality, which in turn displays the corresponding 3D model results in real-time. The dashboard can assist decision-makers and stakeholder groups involved in the protection and renewal of historical villages, thereby enhancing the efficiency of early conceptual design. Moreover, the tool has broader applicability as a design tool across various fields, guiding designers to conduct more scientific and efficient design work.

Balancing historical preservation with modern development is a core issue for the future development of historical villages (Labadi & Logan 2015). To address this, it is crucial to provide designers and researchers with more freedom and intuitive tools to operate dynamic 3D renderings. This would enable them to better analyze, design, and study the historical landscape, architectural changes, and renovation directions of historical villages.

By integrating advanced 3D visualization technologies and enhancing the user

interface of the cross-software evaluation plug-in, which offers a more intuitive and interactive experience. This will empower designers and researchers to seamlessly manipulate 3D models, visualize potential changes, and make informed decisions about preserving historical features while accommodating modern needs.

Furthermore, developing a comparable platform for designers will facilitate collaborative efforts, ensuring that all stakeholders can contribute to the sustainable and balanced development of historical villages. By leveraging these advancements, we can create a more holistic approach to heritage conservation and modernization, preserving the unique cultural identity of historical villages while fostering their growth and development.

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