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A Study of Ethical Issues and Ways of Realizing Ecological Responsibility in the Design of Sustainable Housing

Xiaoxing Hou[1,*]
[1] School of Public Administration, Nanjing Normal University, Nanjing, Jiangsu, 210023, China
Corresponding authors: (e-mail: houxiaoxing@126.com).

Abstract Green eco-housing architecture has attracted much attention in today's environmental context of rapid socio-economic development and continuous improvement of people's quality of life. This study takes design ethics as the theoretical basis and combines the requirements of ecological responsibility in housing design to design a two-dimensional image of sustainable housing. The Canny operator is utilized to detect the edges of the 2D image and extract its contour, the VGG-16 network is used to extract the main features in the 2D image to generate feature vectors, and then the convolutional layer generates the 3D design model of sustainable housing. Subsequently, the SuperMap platform is used as a vehicle to design a sustainable housing design system to realize the ethical issues and ecological responsibility. It is verified that the 3D modeling method proposed in this paper is able to accurately align the sustainable housing design images designed by modeling. It is also found that the building density and green space ratio in the sustainable housing designed based on the methodology of this paper are 21.85% and 42.59%, respectively, which are able to realize the ethical issues and ecological responsibility in sustainable housing design. This paper provides a reference method for the effective design of sustainable housing and lays a strong foundation for the conservation and sustainable development of the earth's ecology.

Index Terms canny operator, VGG-16 network, SuperMap, design ethics, sustainable housing design

I. Introduction

As people's understanding of environmental protection and energy saving and emission reduction becomes clearer, people pay more attention to the natural ecology, which also puts forward new requirements for the building, promotes the transformation of the construction industry, and also lays an important foundation for the sustainable development and progress of the construction industry [1]-[3]. As the planning and creation stage of ecological architecture, ecological architectural design can fully embody the concept of ecological civilization, can accelerate the transformation of ecological architecture as a new type of construction industry from the source, in order to broaden the space for the development of the construction industry. In this context, the ethical and ecological design of sustainable housing has become a compelling theme [4]-[7].

The impact of human design activities on society and the environment is increasing, thus the call for designers to take ethical responsibility for individuals and nature is gradually increasing in today's society, and ethical and ecological reflection on certain design behaviors is becoming more and more urgent, which, coupled with the trend of globalization, has made this concern manifest in a profound and wide-ranging level [8]-[11]. As the most basic living needs of human beings, housing should reflect its ethical needs and express its ethical value at the design level. From the level of design, the most basic is the "functional level", followed by the "aesthetic level", and finally the "ethical level", and its value can be regarded as a higher moral value of design beyond the practical functional value and aesthetic value [12]-[15]. Ethics and ecology in sustainable housing design is a very important theme. Only by taking both ethics and ecology into account in housing design can we realize sustainable development in the true sense and create a better future [16], [17].

Ethics is the study of moral norms and values, which involves people's judgmental standards of behavior and their perceptions of what is right and wrong. Ethics in architectural design is about reminding architects to keep their professional ethics in mind during the design and construction process and to prioritize the public interest and the needs of society. Literature [18] presents the link between ethics and design using DTRS7 data from the Architecture and Engineering Design Conference. The concept of virtual architecture was also used to demonstrate the adaptation of ethical thinking by designers and the involvement of designers in ethics in their design work. Literature [19] reveals that ethical issues arise when new forms of architecture and technology are applied, and an important prop for addressing this issue is the construction performance assessment. The widespread use of BPA requires ethical policies to protect its practice. Literature [20] explores the application of the social dimension of sustainability to the teaching of civil engineering. Based on student assignments in order to assess the impact of the discussion of ethical issues in sustainable urban development on student learning. The students' assignments were analyzed through an activity and the results showed that a short-term intervention was able to promote students' perception of the social impact of technology. Literature [21] discusses the relationship between ethics and architecture. By analyzing the ideological movements of the three doctrines: modern, postmodern and neo-barbarism. It is pointed out that architecture is influenced by ideas and design standards, while professional practice is influenced by the principles of ethics. Literature [22] describes the book “The Ethics of Architecture”, which is about the role of architecture in the world of duty and responsibility and the impact of architects and buildings on human life, the book addresses the dilemmas faced by architectural design related to morality and ethics.

Ecological responsibility in architectural design is particularly important in the current social context. Through measures such as energy saving, rational use of water resources, green building and sustainable design, the damage to the environment can be reduced, the waste of resources can be reduced, and the sustainable development of society can be promoted. Literature [23] emphasizes that it is necessary to rethink the design and technology of the current built environment. It aims to review the reacquisition of a pathway of thinking with the assistance of which the protection and maintenance of the global environment can be realized. Literature [24] suggests that the adoption of an eco-design approach can contribute to the development of 'eco-architecture'. The factors and shortcomings that drive designers to implement eco-design are explained, and through a questionnaire survey, it was found that although designers have a high level of environmental sensitivity, it is still difficult to realize the true use of eco-design methods. Literature [25] analyzes architectural projects with the aim of investigating initiatives to maintain environmental flexibility, with implications such as understanding the impact of ecosystems on architecture, enhancing designers' eco-design of buildings, and so on, leading to sustainable eco-architecture. Literature [26] mentions that the shift in consumer attitudes towards ecology is mainly due to the increased demand for environmental design of private homes. The categorization of the design, planning, and aesthetic principles of a private residential building aims to emphasize the ecological design of private homes. Literature [27] aims to realize ecological housing policies applicable to economic development for decision makers such as governments and builders. Based on snowballing and other methods, and based on surveys and analyses, affordable eco-housing design policies were developed and ranked, and the “recycling” scenario was ranked first.

In this paper, under the guidance of the theory of design ethics, a two-dimensional image of sustainable housing is designed by combining the requirements of ethical issues and ecological responsibility in housing design, so as to realize the ethical issues and ecological responsibility in housing design. Subsequently, the 2D design image is converted into a grayscale map and subjected to double thresholding, and after recognizing the edges and contours of the 2D image by using the Canny operator, Gaussian filtering is used to remove the noise in the image to obtain a binary housing design image with edge information. VGG-16 feature extraction network is used to extract feature points in the image to generate feature vectors, and the feature vectors with anchors are input into the convolutional layer for training to generate 3D modeling images of sustainable housing design. Finally, the sustainable housing design system is built based on SuperMap platform and 3D modeling method, and operations such as visual browsing and 3D analysis of 3D building scenes are performed in order to better realize ethical issues and ecological responsibility. In this study, after verifying the performance of the 3D modeling method, an area is selected as an object for sustainable housing design, and the ecological indicators and energy consumption of the designed housing are analyzed in order to explore the effect of realizing ethical issues and ecological responsibility in housing design.

II. Method

II. A. Design of two-dimensional images for sustainable housing

Design ethics [28] is a discipline of ethical cognition about the cognitive and thinking process of design, which is dominated by human ideology and the use of certain design means for aesthetic creation, and it is a reflection on design ethics, aesthetics, humanities, ecology and other aspects, as well as an ethical reflection on the purpose of the design, the means of the design, and the design results. Based on this, this paper designs a two-dimensional image of sustainable housing that integrates ethical issues and ecological responsibility under the guidance of the basic principles of design ethics. The basic principle of realizing ethical issues and ecological responsibility in sustainable housing design is shown in Figure 1. Design ethics, which links the concept of ethical issues in sustainable housing design with various ecological responsibilities, is a science that applies certain tools to the design of sustainable housing under the ethical issues and ecological responsibility behavioral norms and guidelines that are consciously developed by housing designers. Its mission is to use certain ethical concepts and laws of development in sustainable housing design, based on human beings and specific conditions and environments, correctly set up codes of conduct and ecological responsibilities, and to seek the coexistence, progress, equality, and harmony of human beings and society and ecology and to promote sustainable development through the artificial design of materials in the design of housing.

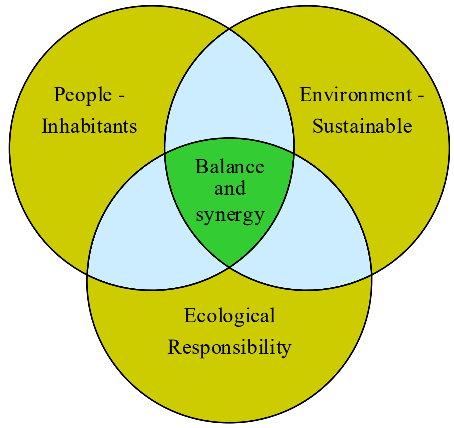

Figure 1: Three relations of sustainable housing design ethics

II. B. Construction of a three-dimensional model of sustainable housing

II. B. 1) Residential Design 2D Image Recognition Methods

A two-dimensional image of sustainable housing based on eco-responsible design ethics is converted into a grayscale map from multi-channel read-in, and after double-thresholding, a dissimilarity operation is performed to obtain a binarized image denoted as THImg, in which the contours of each part of the design map of the sustainable housing have been clearly shown. Recognizing the contours on the basis of this image, edge detection is first performed on the binarized image using Canny operator [29]. The goal is to find an optimal edge detection solution or to find the location of the strongest change in gray intensity in an image.The optimal edge detection is evaluated by three main criteria: low error rate, high localizability and minimum response.

(1) Remove image noise using filtering. Gaussian filtering is used here as an example, which is a process of weighted averaging of the entire residential design image, where the value of each pixel point is obtained from a weighted average of its own value and the values of other pixels in its neighborhood. G_σ is a two-dimensional Gaussian kernel with a standard deviation of σ. A commonly used Gaussian filtering kernel of $5*5$ [30] is shown below:

$$G_\sigma = \frac{1}{2\pi\sigma} e^{-\left(x^2+y^2\right)/2\sigma^2} \tag{1}$$

$$K = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} \tag{2}$$

(2) Calculate the gradient magnitude and direction. First calculate the gradient of the image in the horizontal and vertical directions according to formula (3). Then calculate the gradient magnitude and direction as in Eq. (4), the direction of the gradient is generally divided into four categories, namely, 0 degrees, 45 degrees, 90 degrees, 135 degrees:

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \times I G_y = \begin{bmatrix} -1 & -2 & -1 \\ -0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \times I \tag{3}$$

$$G = \sqrt{G_x^{\ 2} + G_y^{\ 2}} \theta = \arctan\left(\frac{G_x}{G_y}\right) \tag{4}$$

(3) Non-extreme value suppression. Non-extremely large value suppression is applied to the pixel values in the image to filter the non-edge pixels to make the boundary clearer.

The obtained binary image with edge information is taken as input for the next step of contour extraction, which can be done by openCV.

For a given input img, the pixel points at each position are scanned in left-to-right, top-to-bottom order to determine the boundary starting points: the outer boundary and the hole boundary. The pixel value at (I,j) is labeled $f(I,j)$. If $f(I,j)>0$, $f(I,j+1)-0$, then this is the starting point of the hole boundary. If $f(I,j-1)<1$, $f(I,j)>0$, then this is the starting point of the outer boundary.

Set the variable number to an initial value of 1. Use number to number the detected boundary. The rule is that if $f(I_2)>0$, $f(I_2,j+1)<1$, then this is the right endpoint of the boundary point, and $f(I_2)$ is noted as $-1*number$. Otherwise, check if $f(I,j)$ is already numbered, and if not, number $f(I,j)=number$.

A call to the find Contours() API returns a list of arrays, each member of which is a set of points representing a closed contour.

II. B. 2) Image Feature Extraction Methods

The model first passes the original sustainable residential design image into a convolutional neural network based on the classification task, the VGG-16 feature extraction network [31]. The VGG-16 network contains 13 convolutional layers and 3 fully connected layers, which can be used as a feature extractor for extracting the features of the input image, and the generated feature maps are simultaneously used for the subsequent candidate region generation network and classification regression network. The convolutional layers in the whole network use 3×3 convolutional kernels, so that each convolutional layer (tensor) and the previous layer (tensor) maintain the same width and height, which ensures that the same perceptual field conditions to better protect the quality of the image, reduces the parameters of the network, improves the depth of the network, and enhances the effect of the network. The whole network contains five pooling layers (pooling layer has no weight coefficients, does not belong to the weight layer, so it is not counted), all using the same pooling layer parameters 2×2, step size of 2, $\max$ pooling method, which can make the width and height of the tensor after passing through each pooling layer is the width and height of the previous layer $\frac{1}{2}$. The image of any size size is output as a one-dimensional tensor after passing through the VGG-16 network, known as the feature vector.

II. B. 3) Generation of candidate target areas

The feature vector with anchor is simultaneously input into two parallel convolutional layers with convolutional kernel 1×1, one of which is determined by Softmax classification function to determine the confidence level of foreground (target) and background (non-target) within the anchor, and the determination formula is as follows:

$$s_i=\frac{e^i}{\sum_j e^j} \tag{5}$$

where i denotes the i rd element of a j -dimensional vector.

After a convolutional layer with a convolutional kernel of 1×1 that simulates a fully connected layer, a regression operation is done on the target region to output the predicted displacement correction parameters t_x, t_y for the center point of the ANCHOR and the predicted scaling correction parameters t_w, t_h for the length of the ANCHOR edges, which are given by Eq:

$$t_x=\frac{(G_x-P_x)}{P_w} \tag{6}$$

$$t_y=\frac{(G_y-P_y)}{P_h} \tag{7}$$

$$t_w=\log\frac{G_w}{P_w} \tag{8}$$

$$t_h = \log \frac{G_h}{P_h} \tag{9}$$

$$x = w_a t_x + x_a \tag{10}$$

$$y = h_a t_y + y \tag{11}$$

$$w = w_a e^{t_w} \tag{12}$$

$$h = h_a e^{t_h} \tag{13}$$

where x, y, w, h represents the horizontal and vertical coordinates of the center point of the candidate region and the length and width of the region's border. G_i is the true value and P_i denotes the predicted value $(i = x, y, w, h)$.

The training process of RPN is end-to-end, and the optimization methods used are backpropagation and stochastic gradient descent (SGD), and the loss function is the joint loss of classification error and regression error. The formula is as follows:

$$L(\{p_i\}+\{t_i\}) = \frac{1}{N_{cls}} \times \sum_i L_{cls}(p_i, p_i^*) + \frac{\gamma}{N_{reg}} \times \sum_i p_i^* \times L_{reg}(t_i, t_i^*) \tag{14}$$

where, i denotes the i nd ANCHOR point, p_i^* denotes the i th ANCHOR point is a positive sample, t_i is the prediction correction parameter of the ANCHOR box, t_i^* denotes the deviation between the candidate region box and the real target box, and N_{cls} and N_{reg} are constants.

The feature map and the candidate regions generated by RPN are passed into the classification regression network at the same time, and the local maxima are first screened out by the non-maximum suppression (NMS) algorithm, and 300 target frames are extracted among thousands of candidate regions, which greatly reduces the computation time, and the computation formula of the localization accuracy evaluation index IOU is as follows:

$$IOU = \frac{(A \cap A_i)}{(A \cup A_i)} \tag{15}$$

where A is the area of the border with the highest confidence among a set of candidate regions, and A_i is the area of the remaining candidate regions $(i = 1, 2, 3 \cdots)$ except A.

The screened candidate regions are mapped onto the feature map by ROIpooling layer, and pooled into images with the same size and shape, and then entered into the classification network and regression network respectively, whose network structure and algorithm are the same as that of the RPN network, except that the convolution layer in the RPN is replaced with a fully connected layer, which discards the sharing of weights in different positions of the convolution layer, and realizes the further classification of the target and the fine correction of the target frame.

II. C.Systems for realizing ethical and ecological responsibility in housing design

Many domestic 3D GIS products adopt Cseium architecture, such as SuperMap iClient3D for WebGL, which can build a system platform with GIS functions without plug-ins across operating systems and browsers, and can access a variety of services released by SuperMap iServer, realize the functions of 3D scene visualization, human-computer interaction and management of geographic data. The platform can access various services published by SuperMap iServer, realize 3D scene visualization, human-computer interaction, and manage geographic data. Therefore, this paper realizes sustainable housing design integrating ethics and ecological responsibility based on this platform, which is constructed based on the Cseium architecture, and its secondary development can be utilized to browse the scene and carry out spatial analysis in the browser and the mobile terminal in a smooth and clear way. Browser plug-ins need to be installed, can realize two or three-dimensional graphics browsing and related operations, dynamic data display, is a high-quality and popular three-dimensional earth engine. The engine has the following features: support for 2D, 3D and 2.5D view modes; in compliance with the standard can load all kinds of map layers, such as 3D tiles, terrain and other image layers, geometric vector data, etc.; the ability to simulate the time dynamics of the geographic data with a time dimension for 4D visualization. The architecture consists of core layer, renderer layer, scene layer and dynamic scene layer.

This paper is based on the SuperMap platform [32] for system development, mainly by accessing the relevant services released by SuperMap iServer for modular development, through the front-end development to achieve 3D scene visualization browsing, interactive operation and 3D analysis and other functions, to build a network system that runs on multiple operating systems and browsers without plug-ins. The development framework adopts the unified 3D drawing technology standard - HTML5 WebGL, which can be adapted to a variety of operating systems, terminal devices and browsers in the market. Due to the relatively large amount of data in the 3D model of the sustainable housing design, in order to rendering effect and speed of the 3D model, there are certain requirements for the development of hardware and software configuration, the development environment configuration of this paper is shown in Table 1. On the basis of the lightweight three-dimensional client development platform, according to the provision of easy to expand, the development of efficient JavaScripts language development interface, no need to download, install plug-ins can be carried out on the Web side of the functional design and development to achieve terminal access to build a satisfactory three-dimensional visualization system.

Table 1: Development environment

Hardware platform	
processor	Intel(R) Core(TM)i9-10900F CPU @ 2.80GHz (20 CPUs)
Graphics card	NVIDIA GeForce RTX 3080
memory	42G
Disk space	512G
Software platform	
Operating system	Windows 10, 64 bits
3d geographic information system software	SuperMap iDesktop,SuperMap iServer
System development platform	Visual Studio Code,Notepad++
System development language	HTML,JavaScript

III. Results and discussion

III. A. Performance analysis of 3D modeling methods for residential design

III. A. 1) Analysis of alignment point pair extraction results

The main purpose of the experiments in this section is to experiment and analyze the information in the 2D design images of sustainable housing with the residential information generated by the 3D alignment method proposed in this paper, which mainly includes sparse alignment point extraction and sparse alignment point pair matching. In order to quantitatively evaluate the alignment results between the two, comparative experiments and quantitative analyses are carried out by selecting different study areas, and it is concluded that the 3D modeling method proposed in this paper is characterized by high accuracy and strong generalization ability.

In order to quantitatively verify that the 3D modeling method in this paper can correctly extract the corner information in different scenarios of residential design, this paper randomly selects a number of two-dimensional design images of sustainable housing based on design ethics as the research object, uses the proposed method to extract the corner points in the building of the residential design required for the alignment, and manually verifies the extracted corner points in the residential design one by one. The validation information obtained statistically by manual and 3D modeling methods is shown in Table 2. The targets can be accurately extracted in different experimental objects using the 3D modeling method proposed in this paper, and the extraction can be accurate when the buildings in the sustainable residential design are uniformly distributed and the building outlines are simple. In the 2nd, 4th and 6th sustainable housing design images, the accuracy of the 3D modeling method to extract corner points is high, reaching 100%, 97.22% and 97.44%, respectively. However, the existence of complex contour shape buildings leads to errors in the extraction of alignment points, and the CAD representation of the buildings is more detailed, the extracted corner points of the buildings will be more than the corner points of the buildings in the 2D images, and the more the difference between the two, the accuracy decreases. The number of corner points in the 2D image and 3D modeling in the 1st sustainable housing design image are 58 and 65 respectively, and the accuracy rate is only 87.93%, but the error is also within the acceptable range. The experimental results show that the 3D modeling method proposed in this paper can accurately align the sustainable housing design images designed by modeling, help the designer to further adjust the housing design according to the specific modeling situation, and better realize the ethical issues and ecological responsibility in housing design.

Table 2: Extracted information for different experimental regions

Image	Angular points in 2D	3D Angle count	Accuracy rate (%)	Error (%)
1	58	65	87.93%	12.07%
2	26	26	100.00%	0.00%
3	52	57	90.38%	9.62%
4	36	35	97.22%	2.78%
5	48	50	95.83%	4.17%
6	39	38	97.44%	2.56%
7	42	44	95.24%	4.76%

In order to quantitatively verify whether the method can correctly match the alignment point pairs under different grid divisions, the housing design image is divided into three grid sizes, namely 10m×10m, 15m×15m and 25m×25m. The alignment point pair matching is carried out using the method of this paper and the extracted alignment point pairs are verified manually one by one, and the results of the summary of the verification information statistics are shown in Table 3. It can be found that the 3D modeling method proposed in this paper is able to extract the target more accurately in different sizes of meshing. When all the corner points are matched, the accuracy of the grid size slightly increases from 98.52% for 10m×10m to 98.74% for 15m×15m, but when the grid size reaches 25m×25m, the accuracy decreases greatly and only reaches 93.63%. When under different strategies, all corner points, lower-left corner points, decentralized point selection and lower-left corner points, centralized point selection have higher accuracy rates, of which lower-left corner points, decentralized point selection (97.07%) can achieve the highest accuracy rate. Diagonal corner point, centralized point selection has a lower average accuracy rate (93.47%) in this case, mainly due to the fact that the distribution of matching points is denser in this case, and when the distribution of building clusters in the sustainable residential design data source is denser, there will be more than one matching point to be matched in a grid, which will not be able to judge and result in the phenomenon of mis-matching.

Table 3: Matching information for different experimental area alignment pairs

Strategy	Accuracy rate (%)			
	10m×10m	15m×15m	25m×25m	Average
Full Angle	98.52	98.74	93.63	96.96
Corner corner, Dispersion point	98.66	98.89	93.65	97.07
Corner corner, Concentration selection	97.42	98.66	93.64	96.57
Diagonal point, Dispersion point	97.06	97.56	91.87	95.50
Diagonal point, Concentration selection	95.64	95.06	89.72	93.47

III. A. 2) Comparative Analysis of 3D Modeling Efficiency

The modeling operations in this paper's method and SketchUp's method for the three sustainable housing design images were compared, and the results of the comparative efficiency analysis of the two methods are shown in Table 4. The method in this paper is much less than SketchUp (238 operations, 652.93s) for modeling in terms of number of operations (16) and total time (19.84s). The method in this paper typically takes only a few seconds to a dozen seconds to draw a 3D model of a sustainable housing design, and identifying and extracting syntactic parameters from a 2D sketch of the design can be done at an interactive level of speed. In contrast, reconstructing the model in SketchUp requires several minutes or more for continuous push and pull adjustments.

Table 4: Modeling efficiency comparison results

Method	Experimental frequency	Reconstruction efficiency				
		Mouse Down/Up	Mouse Move	Mouse Wheel	Mean Operands	Mean Time (s)
SketchUp	a	68.52	89.74	15.26	238	652.93
	b	73.59	101.48	22.48		
	c	119.58	148.72	45.92		
Ours	a	3.26	7.95	1.42	16	19.84
	b	4.89	8.52	1.52		
	c	8.93	15.87	1.85		

III. B. Example analysis of sustainable housing design

III. B. 1) Design object selection

(1) Site Location

This design practice project is located in an area on the east side of a university campus in X City, S Province. The experimental site is close to the entrance of the east gate of the school, the north and south sides are planted with flowers and plants, the west side faces the main road of the campus as well as the large lawn of the public teaching area, the surrounding scenery is beautiful, and the distance from the activity area is far, the environment is quiet, and the geographical location is superior. The project site covers an area of about 529.48 square meters, and the whole building is divided into two floors, with a total area of 485.26 square meters and a building height of 6.5 meters. The good building performance provides a strong guarantee for the design and construction of sustainable housing that realizes ethical issues and ecological responsibility. This project is based on the theory of design ethics for sustainable housing design, which realizes the ethical issues and ecological responsibility in housing design by rationally planning the spatial layout of the housing, integrating greening, energy saving and intelligence into the design, and creating a comfortable and healthy living environment.

(2) Climate Analysis

The annual precipitation and temperature change curve of S city is shown in Fig. 2, which is a temperate monsoon climate with four distinct seasons, abundant light, sunshine rate of about 55.89%, an average temperature of 9.43 ℃, and an average precipitation of 72.53 mm. Among the four seasons, winter and summer are long, with high temperature and rain in summer and frequent cold waves in winter. Therefore, based on the more favorable climate resources, and according to the requirements of ethical issues and ecological responsibility, a rainwater collection system can be installed in the design of sustainable housing to collect rainwater during the stormy season, and flow into the house through the pipe for the irrigation of green plants, etc., so as to avoid the waste of water resources. In response to the abundant solar energy, roof photovoltaic and solar collectors can be installed to reuse renewable energy to meet the indoor hot water demand.

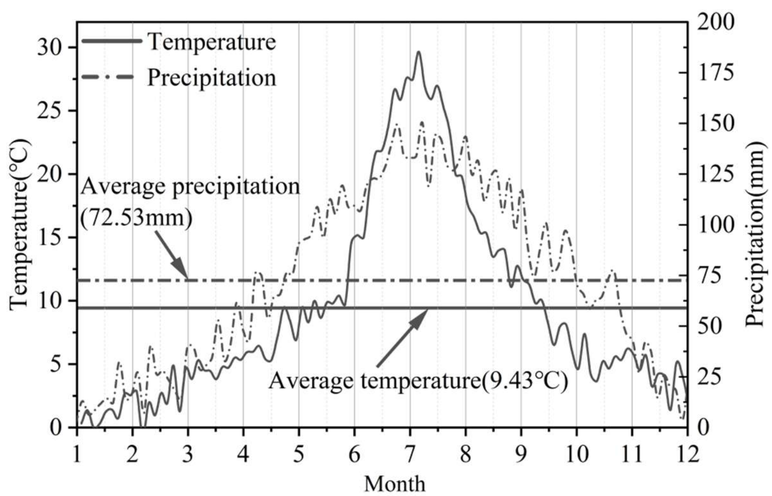

Figure 2: Annual Variation Curve of Precipitation and Temperature

III. B. 2) Analysis of eco-indicators for sustainable housing design

In this paper, based on design theorizing and combined with 3D modeling methodology for sustainable housing design in the study area, the designed sustainable housing is analyzed in terms of ecological indicators from four aspects, namely, ecological housing, ecological landscape, ecological technology, infrastructure, and community management, according to the ethical issues and requirements for realizing the ecological responsibility in the design of sustainable housing and the Ecological Settlement Evaluation Indicator System of the related research. The results of the ecological indicator analysis of the sustainable housing design are shown in Table 5. In the designed sustainable housing, the utilization rate of new or green energy and the building energy efficiency rate in the eco-technology dimension reached 21.23% and 52.49%, respectively. The utilization rate of water-saving appliances and the rates of sewage treatment and standard discharge in the houses were able to reach 100%. In terms of eco-housing indicators, the design of indoor sound, light and heat microenvironments and living spaces is able to realize ethical and ecological responsibility. In addition, the building density and green space rate in the designed residential object are 21.85% and 42.59%, respectively, indicating that the method proposed in this paper is able to realize the ethical issues and ecological responsibility in sustainable housing design.

Table 5: Ecological index analysis results

Technologies	Subsystems	Index content		Residential ecological index
Ecological technology	Green energy technology	New energy use		21.23%
		Building energy saving		52.49%
		Other energy saving measures		5.89%
		Green energy as a cold and hot source ratio		15.69%
	Green technology	General requirement	Utilization of water saving equipment	100%
			Sewage rate	100%
			Water ratio of pipe	95.15%
		Environmental requirements	Garbage collection rate	100%
			Classification rate	87.52%
			Cell acoustic environment	≤35dB
			Indoor acoustic environment	≤28dB
Ecological housing	3r material utilization in wall materials			28.95%
	Indoor sound light heat environment			Meet the requirements
	Space design			Comfort and utility
Ecological landscape	Greening system	The green rate of the community		42.59%
		The green rate of the community		85.94%
		Hard landscape engineering quantity		29.87%
		Vertical green ratio		25.48%
	Natural ecosystem	Ecological wetland		2.89ha
	Artificial ecosystem	Ecological core corridor		15.64ha
		The boundary of the community is left with the green isolation belt		5.94ha
Volume ratio	1.54			
Building density	21.85%			
Green land rate	42.59%			

III. B. 3) Analysis of energy consumption in designed homes

Subsequently, this study analyzes the annual energy consumption of the designed sustainable housing, and since it is a sustainable housing building, lighting, equipment, heating and air conditioning loads are mainly considered in terms of energy consumption. The simulation analysis of residential energy consumption is carried out using specialized software, and the simulation results of indoor annual energy consumption of the building are shown in Figure 3. The energy consumption of lighting and equipment in sustainable housing is between 0-500kWh and 0-1000kWh respectively, and the heating energy consumption is higher in January and December, which can reach about 5000kWh. The air-conditioning cooling load reaches a maximum of 2000kWh. Compared with the energy consumption of existing residential buildings, the energy consumption of the sustainable house designed by the method of this paper is at a low level.

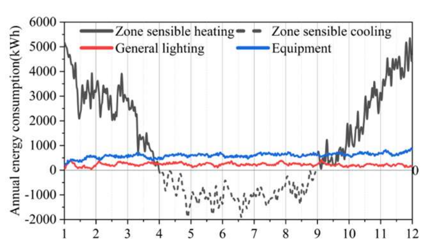

Figure 3: Analysis results of annual energy consumption analysis

IV. Conclusion

Sustainability-based housing design research aims to integrate environmental protection and sustainable development into architectural design to reduce the consumption of natural resources and environmental pollution. This study designs sustainable housing design images based on ethical issues and ecological responsibility with the theoretical support of design ethics, and uses deep learning networks to extract feature points in 2D images to achieve 3D modeling. Then the sustainable housing design system is constructed to optimize the design of sustainable housing through visual browsing and other processes to better realize the ethical issues and ecological responsibility.

The validation results of the 3D modeling method show that the accuracy of the 3D modeling method in extracting the corner points in the three sustainable housing design images with simple contours is high and can reach 100%, 97.22% and 97.44%. It indicates that the 3D modeling method proposed in this paper can accurately align the sustainable housing design images designed by modeling and help the designer to further adjust the housing design according to the specific modeling situation. The empirical design study found that the utilization rate of new or green energy and the building energy efficiency rate of the sustainable housing designed based on the methodology of this paper reached 21.23% and 52.49%, respectively. The energy consumption of lighting and equipment in sustainable housing is between 0-500kWh and 0-1000kWh respectively, which is a low level of energy consumption.

In conclusion, the methodology proposed in this paper is able to realize the ethical issues and ecological responsibility in sustainable housing design. The popularization and application of the method is important for achieving sustainable urban development and protecting the earth's environment.

References

[1] Pataki, D. E., Santana, C. G., Hinners, S. J., Felson, A. J., & Engebretson, J. (2021). Ethical considerations of urban ecological design and planning experiments. Plants, People, Planet, 3(6), 737-746.
[2] Kärrholm, M., & Kopljar, S. (2020). Built environment, ethics and everyday life. Urban Planning, 5(4), 101-105.
[3] Keitsch, M. (2012). Sustainable design: A brief appraisal of its main concepts. Sustainable Development, 20(3), 180-188.
[4] Birkeland, J. (2022). Nature positive: interrogating sustainable design frameworks for their potential to deliver eco-positive outcomes. Urban Science, 6(2), 35.
[5] Isais, G. F., & Harjo, L. L. (2016). Social equity and ethics in design of sustainable built environments. In The Routledge Companion for Architecture Design and Practice: Established and Emerging Trends (pp. 203-210).
[6] Raymundo, M. G., Matheus, C., & de Moraes Hoefel, J. L. (2019). Awareness of Sustainability Issues: Holistic Housing Sustainable Thinking. Encyclopedia of sustainability in higher education, 76-83.
[7] Papanek, V. (2022). The green imperative: ecology and ethics in design and architecture. Thames & Hudson.
[8] Boy, G. A. (2017). A human-centered design approach. In The handbook of human-machine interaction (pp. 1-20). CRC Press.
[9] Design, D. C. (2017). What is human-centered design. Medium, August, 14.
[10] Boy, G. A. (2017). Human-centered design as an integrating discipline. Journal of Systemics, Cybernetics and Informatics, 15(1).
[11] Johnson, T., Das, S., & Tyler, N. (2021). Design for health: human-centered design looks to the future. Global Health: Science and Practice, 9(Supplement 2), S190-S194.
[12] Palmer, J., Instone, L., Mee, K. J., Williams, M., & Vaughan, N. (2015). Green tenants: practicing a sustainability ethics for the rental housing sector. Local Environment, 20(8), 923-939.
[13] Adhya, A., & Plowright, P. D. (2015). Sustainable Architecture as Ecology: Defining shared systemic priorities of public health and social ethics in places. Architecture and Sustainability: Critical Perspectives for Integrated Design: Acco, Uitgeverij.
[14] Gražulevičiūtė-Vileniškė, I., & Narvydas, A. (2012). Environmental Ethics and Sustainability in Housing Design. Environmental Research, Engineering and Management, 62(4), 68-80.
[15] Poor, J. A., Thorpe, D., & Goh, Y. (2018). The key-components of sustainable housing design for Australian small size housing. GEOMATE Journal, 15(49), 23-29.
[16] Shama, Z. S., & Motlak, J. B. (2019, May). Indicators for Sustainable housing. In IOP conference series: materials science and engineering (Vol. 518, No. 2, p. 022009). IOP Publishing.
[17] Prochorskaite, A., Couch, C., Malys, N., & Maliene, V. (2016). Housing stakeholder preferences for the “Soft” features of sustainable and healthy housing design in the UK. International journal of environmental research and public health, 13(1), 111.
[18] Lloyd, P. (2022). Ethical imagination and design. In About Designing (pp. 85-99). CRC Press.
[19] Sharpe, T. (2019). Ethical issues in domestic building performance evaluation studies. Building Research & Information, 47(3), 318-329.
[20] Andrade, N. A., & Tomblin, D. (2018, June). Engineering and sustainability: The challenge of integrating social and ethical issues into a technical course. In 2018 ASEE Annual Conference & Exposition.
[21] Abusaada, H. (2019). Ethics of Architecture or Ethical Architecture?. International Journal of Responsible Leadership and Ethical Decision-Making (IJRLEDM), 1(2), 1-15.
[22] Kingwell, M. (2021). The ethics of architecture. Oxford University Press.
[23] Wiryomartono, B. (2022). Sustainability and the Built Environment: The Search for Ethics Based on Environmental Awareness and Social Responsibility. In Architectural Humanities in Progress: Divulging Epistemology, Ethics, and Aesthetics of the Built Environment and Habitation (pp. 229-244). Cham: Springer International Publishing.
[24] Annunziata, E., Testa, F., Iraldo, F., & Frey, M. (2016). Environmental responsibility in building design: an Italian regional study. Journal of cleaner production, 112, 639-648.
[25] Attiya, E. E., Shebl, M. A., & Darwish, M. A. M. (2023, February). Applying the Eco-Technological and Ecological Design on Architecture. In International Architecture and Design Conference (pp. 275-296). Cham: Springer Nature Switzerland.

[26] Geng, Z. (2024). Exploring Visual Features of Ecological Design in Private Housing: Search for Visual Principles. HERD: Health Environments Research & Design Journal, 19375867241276284.
[27] Zameni, M., & Razaghi Asl, S. (2021). Developing and prioritizing affordable ecological housing design policies; case study: Minoo Island. Housing and Rural Environment, 40(176), 57-70.
[28] Yuchen Xia,Lu Wang & Yueyao Wang. (2024). The contemporary significance of modernist design ethics. Academic Journal of Humanities & Social Sciences(1).
[29] Lei Yan. (2024). Research on Binocular Vision Image Calibration Method Based on Canny Operator. Automatic Control and Computer Sciences(4),472-480.
[30] Piretzidis Dimitrios & Sideris Michael G. (2022). Expressions for the calculation of isotropic Gaussian filter kernels in the spherical harmonic domain. Studia Geophysica et Geodaetica(1-2),1-22.
[31] Xujie He,Jing Jin,Yu Jiang & Dandan Li. (2024). A lightweight convolutional neural network-based feature extractor for visible images. Computer Vision and Image Understanding104157-104157.
[32] Li Xiaowen,Shen Chen,Zhang Jinlan & Wei Xiaojuan. (2023). SuperMap-Based Research on the Spread Situation and Visual Monitoring Platform of Major Health Events. Studies in health technology and informatics261-270.