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Application of Building Information Model (BIM) in the Design of Marine Architectural Structures

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ABSTRACT

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Aiming at the problem of low visual accuracy in the design of offshore building structures, this paper puts forward the application of BIM in the design of offshore building structures. In the process of using BIM technology, the design of unmarked marine building structures can be effectively marked by these BIM technologies. In order to evaluate the effectiveness of the algorithm, a hybrid feature is used to represent the structural design of offshore buildings, so that the stereo disparity generation process can be completed quickly. The experimental results show that the proposed building information model (BIM) can effectively generate stereo parallax in virtual scenes.

ADDITIONAL INDEX WORDS: *Structural design of marine architecture, building information model (BIM), hybrid feature, stereo disparity.*

INTRODUCTION

Stereo parallax generation of offshore building structure design is a research hotspot in the field of computer vision (Mazumder *et al*., 2015). This technology has a wide range of applications, including structural design monitoring of offshore buildings, and human-computer interaction (Shiers *et al*., 2017). However, the design of offshore building structures has unique characteristics, so it is difficult to characterize their appearance (Laver *et al*., 2012). It is also affected by other factors such as light, occlusion, etc. (Burch *et al*., 2015). At present, many methods of structural design of marine buildings with stereo parallax have been developed based on building information model (BIM) (Lee *et al*., 2017). At present, there are few studies on the application of BIM in the field of stereo parallax generation of offshore building structural design. Building Information Model (BIM) technology is very easy to obtain a lot of unmarked offshore building structural design.

In order to solve this problem effectively, this paper proposes a method of generating stereo parallax by building information model (BIM) technology (Eguaras-Martínez *et al*., 2014). Firstly, the virtual reality technology is determined by building information model (BIM) technology. With the development of stereo parallax generation process, the design of offshore building structure can mark the design of unmarked offshore building structure. Then, the design of offshore building structure can be damaged by classifier. The bad degree is calculated, from which the unmarked offshore building structure design with high degree of stereo parallax generation is classified into the marked offshore building structure design library.

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BIM TECHNOLOGY

BIM technology takes a single component or object in a construction project as a basic element, organizes the geometric data, physical characteristics, construction requirements, price information and other relevant information to form a data-based building model, which serves as the database of the whole construction project. These data organized around building components or objects not only simply reflect the geometric characteristics and physical attributes of building elements, but also maintain the spatial and logical relations as a part of the whole building. As a digital building in virtual space, a complete and hierarchical information system has been formed. BIM has the ability to carry all kinds of information. The whole building-related information and a set of design documents are stored in the integrated database. All the information has been digitized and completely interrelated. It can build a platform for all professions to work together on BIM. This not only eliminates the incompatibility of previous professional design software and communication channels, but also achieves the information sharing and effective management of various professions. In the whole life cycle of a project (decision-making, design, construction, operation, management, reuse after demolition, etc.), each specialty can extract the data they need in BIM according to their own needs to complete their own decision-making, analysis, design, management and other purposes. At the same time, information obtained from BIM is constantly added to BIM to provide information for other professions. In this way, all participants in the project are closely linked through BIM, and the purpose of collaborative work is achieved.

At present, Autodesk AutoCAD is the most widely used software in offshore platform design in China, which is still in the traditional two-dimensional design mode. The popularity of CAD technology greatly improves the design efficiency and reduces the occurrence of design errors, but this design method has been difficult to meet the rapid development of marine engineering design needs, mainly manifested in:

(1) In the current platform design process, the designers must conceive the three-dimensional structure of the platform, then draw and express the two-dimensional graphics with lines, and add various dimension labels. The workload is heavy and cumbersome, so they cannot concentrate on the optimization design and creative design of the platform structure.
(2) Visualization is poor, communication difficulties and owners exchange platform design concepts cannot visualize the overall picture of the platform, information exchange difficulties.
(3) Design errors inevitably lead to large scale and high cost of offshore platform construction, so it is necessary to reduce the possibility of errors in practical projects. However, in actual construction, due to the complexity of the project, many unexpected problems will arise in the design process, which will often lead to rework and delay of the project, resulting in unnecessary losses.
(4) In the process of submitting for examination and construction, design changes and modifications of difficult design drawings will change and adjust, requiring modification and supplement of drawings, and redrawing and re-labelling of drawings without database support will greatly reduce work efficiency.
(5) Version control is difficult. A design task from design to proofreading, auditing and validation has to go through many links. Engineering drawings and design documents need to be revised many times. Many intermediate versions will be produced, and every designer's drawings sometimes have version confusion. Because there is no auxiliary management software, strict version control is difficult.

STRUCTURAL DESIGN OF MARINE ARCHITECTURE

Visual simulation of ocean engineering has always been a difficult point in ocean research. Ni Hongyu has used INVENTOR software to simulate the interference between structural members and lifting during block hoisting, which not only solves the collision problem, but also shows the whole process of platform implementation, predicts the potential safety hazards in site, and increases the safety performance of marine engineering implementation. Because of the scarcity of real application cases and the lack of relevant practical experience, the research work is difficult. At present, the visualization simulation of ocean engineering is mainly based on the two-dimensional simulation of the technical design of marine engineering equipment products. Because the research data software and methods are relatively few and single, the visual simulation research of ocean engineering has not covered the whole ocean engineering project. It is necessary to study the application of BIM technology in visual simulation of ocean engineering. 1. How to apply BIM technology to ocean engineering? First of all, we can optimize the mechanism design, structure and drilling and completion process of ocean engineering projects through improvement. In the pre-project price budget, engineering structure design, technology formulation, structure and completion construction, the visual simulation of the project is carried out to monitor and manage the whole project, establish engineering model in the early research and design stage, and share information with the post-project implementation, trial use and operation. In the process of project implementation and construction, it is necessary to construct and formulate the general opening plan, and to use the information model of every link such as research and design.

Table 1. *Structural design of marine architecture relationship table.*

	hicorrect(1)	hicorrect(1)
hjcorrect(1)	N^{11}	N^{10}
hjwrong(0)	N^{01}	N^{00}

Visualization of ocean engineering involves not only static data with spatial geographic location, but also a large number of dynamic relationships. Therefore, the most basic need is to establish a real and accurate ocean engineering project model. The following are several models that need to be built in the process of visual simulation. Static model is not only the basis of smooth and efficient implementation of the project, but also the key point of the project development plan and the process of structural design and construction planning. Selecting Revit software to establish static model is conducive to reasonable adjustment of the project quotation and conceptual design. Later, static model is transformed into dynamic entity model. Geographic form model of completion site is an important part of three-dimensional digital model, which plays a supplementary role to other models. Geographic form of completion site is the basis of trial voyage and geographic location determination of equipment products in offshore factories, and also the location of offshore engineering project layout and drilling site. In the process of visual simulation, civil 3D is used to build the model, which can show the working situation of the project site to the ocean workers, and is also conducive to the launching test and completion of the well. During the implementation and construction of ocean engineering, the products of ocean engineering are constantly changing, which can be called dynamic entity model. The offshore engineering platform is divided into different and related modules by using the technology of CAD real model building. The bearing capacity of offshore engineering platform in hoisting is tested, and the preparatory work for the construction of offshore engineering platform is done in the early stage.

If h_i,h_j represents two view-building information model (BIM), and the two are not the same, then the relationship between the two can be described in Table 1.

As shown in Table 1 above, N11represents the number of Structural Design of Marine Architectures of h_i,h_j that can be correctly classified. N10 represents the correct classification of h_i,h_j indicates the number of misclassifications in the Structural Design of Marine Architecture. Other indicators have similar meanings. In this article, the measurement of virtual reality differences is performed through the Building Information Model (BIM):

$$Q_{ij}(h_i, h_j) = \frac{N_{11}N_{00} - N_{01}N_{10}}{N_{11}N_{00} + N_{01}N_{10}} \quad (1)$$

As shown in Algorithm 1, it represents a specific algorithm implementation process

Input:S represents the initial test set, then T represents the initial classifier set $\{h_1, h_2, ..., h_N\}$, number of iterations M.

The specific process is:

1. For $i, j = 1, 2, ..., N$
2. Through the test set, the stereo classification parallax generation rate p_i of the test classifier h_i can be effectively analyzed and the stereo parallax generation can be defined, which can be defined as $p_i = \frac{TP}{TP+FP}$.
3. $p_i \leftarrow Reg\_rate(T, h_i)$
4. end for
5. Sort $h = \{h_{i1}, h_{i2}, ..., h_{iM}\}$ according to the size of stereo disparity generation rate p_i
6. Pick out the top K classifiers $A = \{h_1', h_2', ..., h_N'\}$, 1<K<N
7. For each $h_i' h_j' \in A$
8. Calculate the difference between two virtual reality: $Q_{ij}(h_i, h_j) = \frac{N^{11}N^{00} - N^{01}N^{10}}{N^{11}N^{00} + N^{01}N^{10}}$.
9. end for
10. Sort the variability values $\left\{Q_{i,j}^{(1)}, Q_{i,j}^{(2)}, ..., Q_{i,j}^{((N-1)\times(N-1))}\right\}$ of all virtual reality calculated in order of magnitude so that the M classifiers with the greatest variability can be found.
11. Output: The M base classifiers $H = \{BL_1, BL_2, ..., BL_M\}$ obtained in the previous step are successfully output.

EXPERIMENTAL RESULTS AND ANALYSIS

Unique Characteristics of Marine Architectural Structural Design

It is important to capture the important parts, appearance and spatial pattern of offshore building structure design by building information model (BIM) technology, and the corresponding coordinate positions are expressed in coordinates. In total, there are many important parts and spatial patterns, including the center of the trunk, the spatial pattern of the left and right wrists, the geography of the left and right ankles and so on. By setting the poles and the center points, the other nodes can be effectively transformed by coordinate transformation, and finally the coordinates shown in the following formula (2) can be obtained:

$$(r_i, \varphi_i) = \begin{cases} r_i = \sqrt{(y_i - y_c)^2 + (x_i - x_c)^2} \\ \phi_i = \arctan\left(\frac{y_i - y_c}{x_i - x_c}\right) \end{cases}, \ i = 1, ..., 11 \quad (2)$$

The coordinates of the center point and other geography in the plane coordinate system are shown in $(xc, yc), (xi, yi)$ in turn, as shown in Figure 1:

The obtained geographic coordinates are normalized, and a minimal operation is performed, namely Formula (3) and Formula (4), to ensure that the data range is between 0-1.

$$r_i' = \frac{r_i - \min\_r}{\max\_r - \min\_r} \quad (3)$$

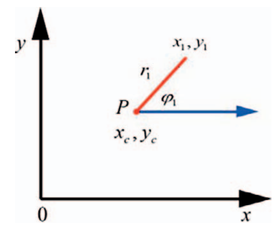

Figure 1. Skeleton geographic coordinate transformation of structural design of marine architecture.

$$\varphi_i' = \frac{\varphi_i - \min\_\varphi}{\max\_\varphi - \min\_\varphi} \quad (4)$$

In the above equations, min_r and max_r in turn show the upper and lower limits of the original value, which similar with min_φ and max_φ, it shows the maximum and minimum value of the original φ. After it is normalized, it is able to obtain geography-based Structural Design of Marine Architecture description (joints based polar coordinates descriptors, abbreviation JPCD), and it has a translation transformation feature.

$$JPCD = \{JPCD_1, JPCD_2, ..., JPCD_{22}\} \quad (5)$$

Method Evaluation

Figure 2 shows the results of the pairing based on JPCD + SRD using the conventional stereoscopic parallax generation algorithm and the algorithm of this paper. The values of the i-th row and the j-column in the confusion matrix represent that the Structural Design of Marine Architecture belonging to the i-th category at this time is the basic probability of incorrectly dividing into the class j. Analysis of Figure 3 shows that on the data set of JPDC+SRD, the effect obtained by the algorithm of this paper is higher than that using the conventional restoration method.

As shown in Figure 3 below, the results obtained when the data set is a single feature set are shown. Analysis yields that the results obtained by modern digital technology methods have a higher recovery rate than the use of restoration methods.

As shown in Table 2, when the feature and feature combination are different, the BIM method proposed in this paper is compared with the conventional stereo disparity generation method, and the results are obtained. From the

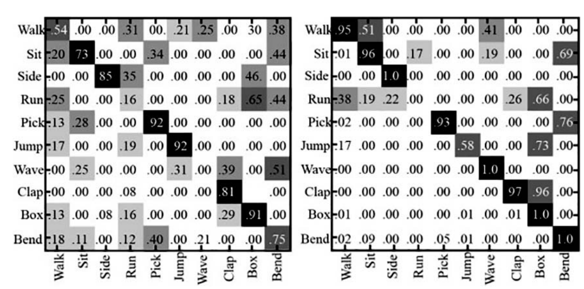

Figure 2. Stereo disparity generated confusion matrix by Structural Design of Marine Architectures, using JPCD + SRD feature data sets.

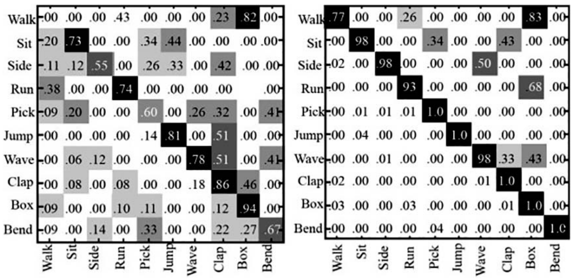

Figure 3. The three-dimensional parallax of offshore building structure design generates confusion matrix using feature data sets. (a) SRD+JPCD feature data set (b) SRD feature data set (c) JPCD feature data set.

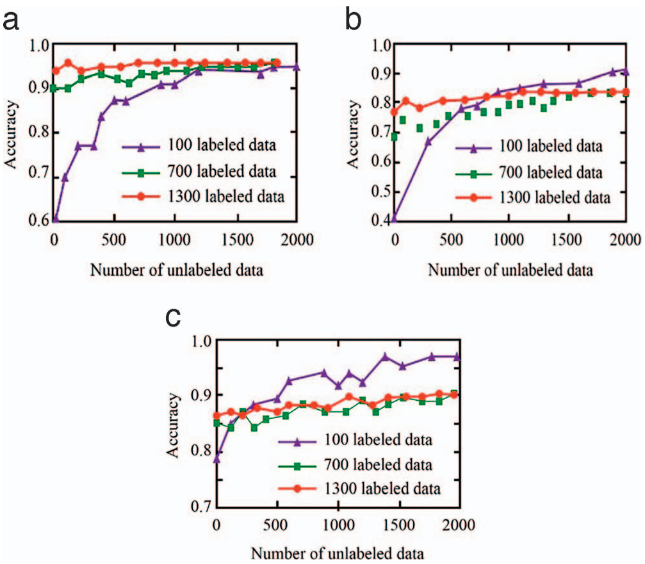

Figure 4. The influence of the number of unmarked Structural Design of Marine Architectures on the viewpoint-related LOD quad tree.

above results, it can be concluded that the stereo disparity generation effect of the proposed method under three criteria is good.

As shown in Figure 4, it is shown that the accuracy of the viewpoint-building information model (BIM) is affected by the labelled Structural Design of Marine Architecture under different feature data sets.

Table 2. *Stereoscopic parallax generation accuracy using building information model (BIM) strategy.*

Feature descriptor	Precision		Recall		F-Measure	
	LABELED	ASTGM	LABELED	ASTGM	LABELED	ASTGM
JPCD+SRD	0.62	0.94	0.62	0.93	0.63	0.95
SRD	0.63	0.99	0.61	0.95	0.62	0.97
JPCD	0.81	0.98	0.82	0.96	0.71	0.97
Avg	0.71	0.95	0.73	0.98	0.63	0.96

CONCLUSIONS

In this paper, building information model (BIM) technology is applied to the study of stereo parallax generation in offshore building structure design. The choice of virtual reality is realized through the selection method based on building information model (BIM). Moreover, in the process of generating stereo parallax, the damage degree setting of the structure design of ocean buildings in virtual reality can effectively estimate the stereo parallax generation degree of the structure design of ocean buildings in this paper. Through the research results, it can be found that the BIM technology has been fully applied to the design of unmarked offshore building structures, and the generalization ability of the whole offshore building structural design system has been greatly improved.

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