

## Research on CAD Key Technology for Crystal Lamps with Linear Distribution

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**Abstract:** With colorful and changing light effect, crystal lamp has become the first choice for the indoor lighting facilities. Crystal lamps have many identical or similar elements in structure, so using CAD technology can assist the designers for the design and modeling of crystal lamps rapidly. In this paper, starting from the structural characteristics of crystal lamps, the crystal lamps are divided into three types, namely linear distribution, plane distribution and 3D distribution. The crystal lamps of linear distribution can be classified into equal distance of main crystal monomer and unequal distance of monomer. Aimed at the two situations, a mathematical analysis is made on the distribution of main crystal, and the respective pseudo code is given. VB language is applied to develop the parameter modeling plug-in applicable to the auxiliary design of crystal lamps based on Rhinoceros platform, and the designers design plug-in to automatically complete the 3D model creation of crystal lamps by selecting parameters and assigning value to the variables, thus achieving the parameter modeling and improving the design efficiency.

### Introduction

Lamps are an important part in the indoor environment, the colorful and changing effect or crystal lamps creates a romantic and warm atmosphere, attracts a lot of consumers, at present, crystal lamp has become the preferable lamp selected by many households when decorating houses[1]. Crystal lamps usually will have layered pendants, most of which are of regular arrangement, but in the process of modeling of crystal lamps, the designers can only complete the modeling manually and repeat the operation for many times. Once the operation is completed, in case of error, it is quite complicated to modify, which greatly increases the burden of designers. Today, the digital development has provided a great creation display space for the designers of crystal lamps, and using CAD technology to assist designers for rapid modeling of crystal lamps has become an inevitable trend. In this research, based on Rhinoceros software, VB language is applied to develop an auxiliary design plug-in of crystal lamps.

In the analysis on the structural characteristics of crystal lamps, they can be classified into three basic types, namely linear distribution, plane distribution and 3D distribution[2,3,4]. The linear distribution means that the main crystal monomer of the lamps is of linear or curve distribution, as shown in Fig.1.



Fig.1 Crystal lamps of linear distribution

Aimed at the design thought of the designers and CAD system characteristics, the design process of crystal lamps of linear distribution is proposed in this paper, as shown in Fig.2.

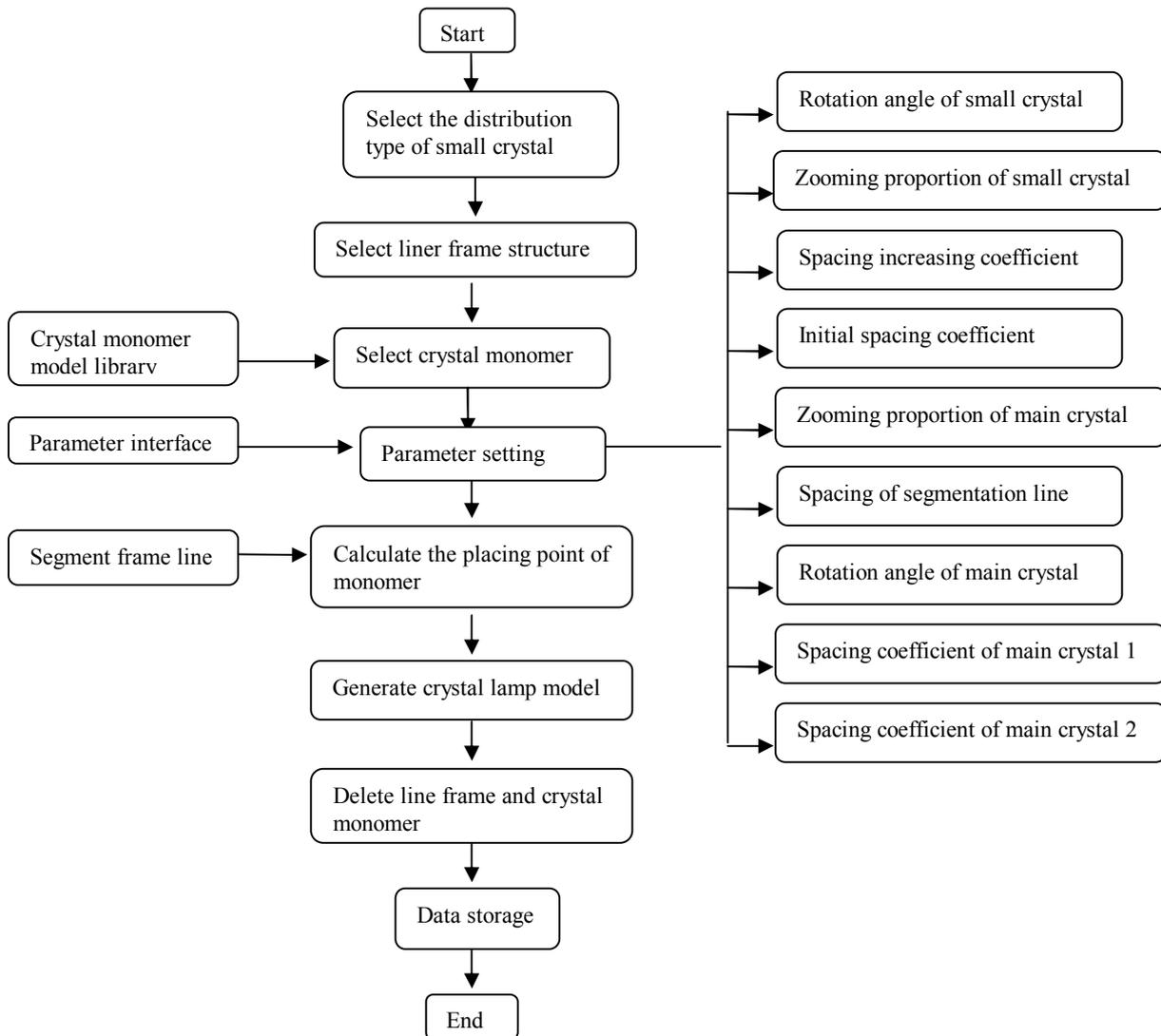


Fig.2 Design flowchart of crystal lamps of linear distribution

### CAD key technology for crystal lamps of linear distribution

The key technology for the rapid design of crystal lamps with linear distribution is to segment the linear frame and save the segmentation point. There are mainly two methods to select the treatment methods: first, the segmentation point is directly taken as the distribution point of crystal monomer; second, some segmentation points are selectively taken as the distribution point of crystal monomer. The first method is aimed at the crystal lamp types with simple structure and no great change in the size of crystal monomer; the second method is mainly aimed at the types with complicated structure, alternate distribution of main crystal monomers and different sizes.

Two methods of segment segmentation are provided in Rhinoceros script: (1) DivideCurve() function is used to achieve the division of segment, as shown in Fig.3. (2) DivideCurveLength() function is used to achieve the division of segment, as shown in Fig.4. In the actual treatment of linear frame of crystal lamps, the segmentation of combining the two methods is usually used.

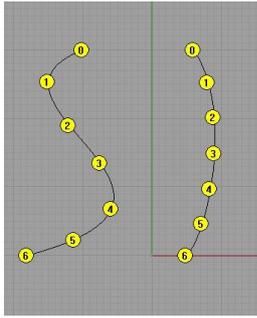


Fig.3 Segmentation method 1

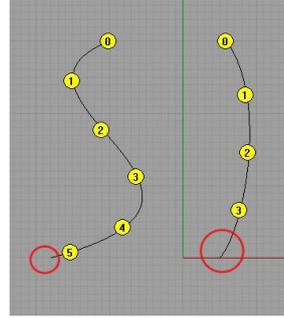


Fig.4 Segmentation method 2

### Equal spacing of main crystal monomer

The equal spacing of main crystal monomer is the most common and basic type in the crystal lamps, the linear frame is segmented according to the spacing value provided by users, the segmentation point is kept, and the segmentation point is taken as the distribution point of main crystal monomer.

#### Equal spacing distribution of single main crystal

Main steps to select the distribution type of small crystal and control the distribution of small crystal through modeling panel: First, segment the suspension wire of main crystal and save the segmentation point; Second, judge whether the segmentation point is on the surface of the modeling plane or inside it, and whether the modeling plane is a closed surface; Third, distribute small crystals on the segmentation points on the surface of and outside the modeling plane, as shown in Fig.5.

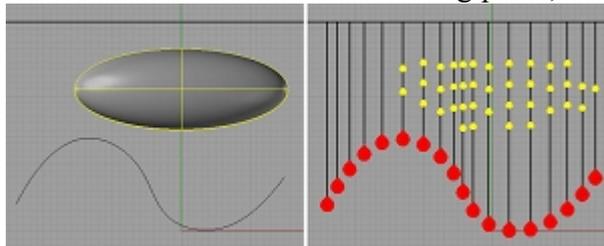


Fig.5 Equal-spacing distribution of single main crystal

#### Selective alternate distribution of two main crystals

Users select the distribution type of small crystals, as shown in Fig.6. Users input the number  $n$  of main crystal 1 between the adjacent main crystal 2 and use a conditional statement to realize it, and its pseudo code is as follows:

```

Segment linear structure, determine the segmentation point;
For  $i=0$  to number of segmentation points-1
Calculate the ratio between  $i$  and  $n$ 
If judge whether the ratio is an integral number, then
Copy the main crystal 1 to the segmentation point;
Put the main crystal 1 in layer 1
Distribute the small crystals selectively
.....
Else
Copy the main crystal 2 to the segmentation point;
Put the main crystal 2 in layer 2;
Distribute small crystals selectively
.....End if
Next

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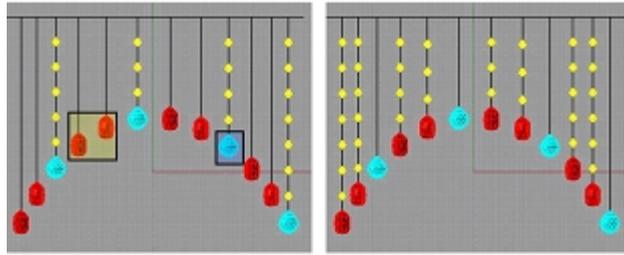


Fig.6 Equal-spacing alternate distribution of two crystals

**Two crystals are distributed up and down based on the morphology center of linear frame**

Distribute the small crystals selectively, as shown in Fig.7. The center of linear frame form is calculated according to BoundingBox() function, judge the size of coordinate of linear frame segmentation point and central point in Z axis, and its pseudo code is omitted.

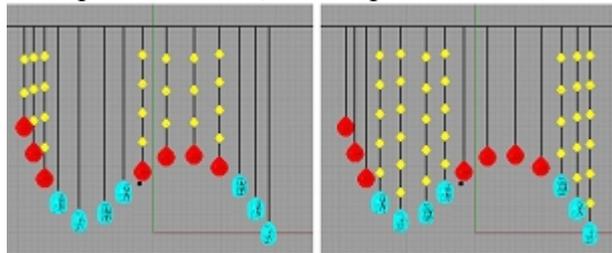


Fig.7 Equal-spacing distribution up and down of two main crystals based on the morphology center

**Unequal spacing of main crystal monomer**

The crystal lamps of unequal spacing of main crystal monomer are relatively complicated in modeling and difficult in technology. The treatment can be divided into the following three steps:(1) Divide the segment, with minimum segmentation spacing as far as possible, and take the spacing as the minimum processing unit, as shown in Fig.8(1). (2) Redistribute and combine the segmentation spacing of the previous step as needed, as shown in Fig.8(2), where the yellow points are taken as the separator to determine the spacing of each combination, as shown in the yellow circles in Fig.8(3). (3) Calculate the central point of each combination spacing, as shown in the yellow points in Fig.8(4).

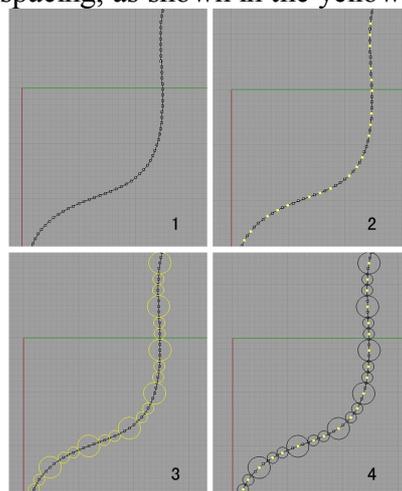


Fig.8 Treatment method of unequal spacing

**Selective alternate distribution of two main crystals**

The adjacent spacing is obviously different, as shown in Fig.9. Method to calculate the total number of segmentation points sumN1 contained by all combination spacing 1:First, take the single combination spacing 1 and combination spacing 2 of a times as a small integrity, first calculate the number of small spacing minM contained by the small integrity, and then calculate the ration minN between M and minM.Second, extract the integral intN and reminder nodN of minN;Third, judge the relation between intN and 2\*N1, if intN1 is not more than 2\*N1, use formula (1) to calculate sumN1; if intN1 is more than 2\*N1, use formula (2) to calculate sumN1;

$$\text{sumN1}=(\text{intN})*(2*\text{N1})+\text{modN}+1 \quad (1)$$

$$\text{sumN1}=(\text{intN}+1)*(2*\text{N1})+1 \quad (2)$$

Use formula (3) to calculate the total number of segmentation points sumN2 contained in the combination spacing 2.

$$\text{sumN2}=\text{m}+1-\text{sumN1} \quad (3)$$

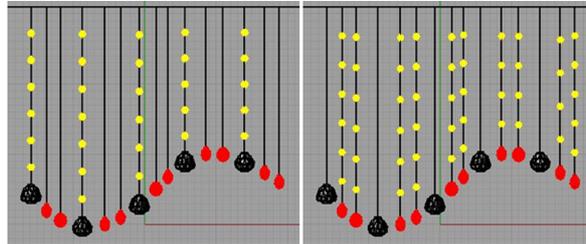


Fig.9 Selective alternate distribution of two main crystals

### Arithmetic increasing of spacing and size of single main crystal

As shown in Fig.10, the linear frame is divided into M segments at an equal small distance d, the first combination space input by users contains half of the number of small distance N1, and the progressive space input contains half of the number of small space N2. The small distances contained in each combination form an arithmetic progression, and through the summation of arithmetic progression, a quadratic equation is obtained, and formula 1-4 is used to calculate the number of combination spaces comN.

$$\text{comN}=\{\text{N2}-2*\text{N1}+\text{sqr}[(2*\text{N1}-\text{N2})^2+8*\text{N2}*M]\}/(2*\text{N2}) \quad (4)$$

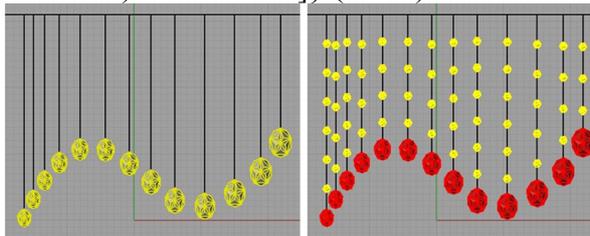


Fig.10 Spacing and size increasing of single main crystal

### Spacing and arithmetic decrease of single main crystal

As shown in Fig.11, aimed at the crystal lamps of arithmetic decrease of main crystal spacing, there are two treatment methods: first, user set the initial spacing and the decrease value of adjacent spacing; second, use reverse thinking and take the spacing arithmetic decrease as the arithmetic increase reversely.

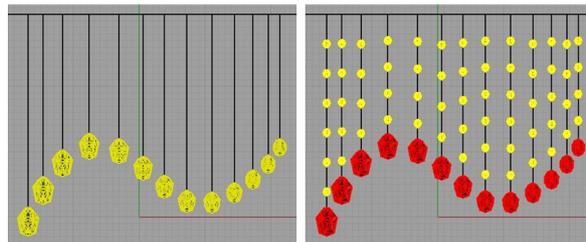


Fig.11 Spacing and size decrease of single main crystal

## Design practice of crystal lamps of linear distribution

Generally, the crystal lamp modeling of linear distribution is combined with equal spacing distribution of main crystal and unequal spacing distribution, the frame structure is usually not a single line, and there are the methods of more frame lines in the frame structure: first, the frame with the same distribution method of main crystal is classified into one type, and then generate the crystal lamp 3D model step by step. The design example of crystal lamp of linear distribution is as follows:

First, based on Rhinoceros software, the designers create a linear fame structure and crystal suspension line hanging plane manually, the suspension plane determines the length of crystal suspension rope, and the frame structure contains two frame lines, as shown in Fig.12, and the blue frame line is treated first;

Second, run the plug-in, select the small crystal distribution type, type of crystal monomer, call in the crystal monomer model and the users input the value of parameter variables;Third, design the plug-in to automatically generate the 3D model of crystal lamp part, and delete the blue frame line and the crystal model called in and put the crystals of the same type in the same layer for convenience of selection; After treating the blue frame line, treat the black frame line according to the same steps above, and generate a complete 3D model of crystal lamps, as shown in Figure 13, the yellow shows the equal-spacing distribution of main crystals, and red shows the internal distribution of main crystal, with interval parameter “3”.

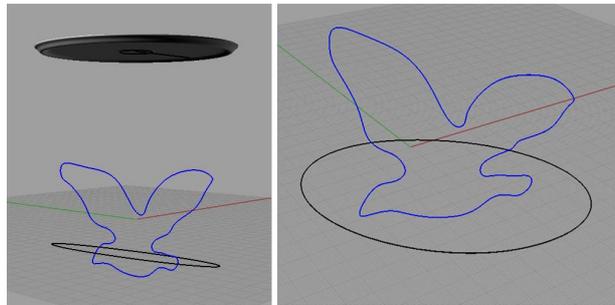


Fig.12 Crystal hanging rope suspension plane and linear frame structure

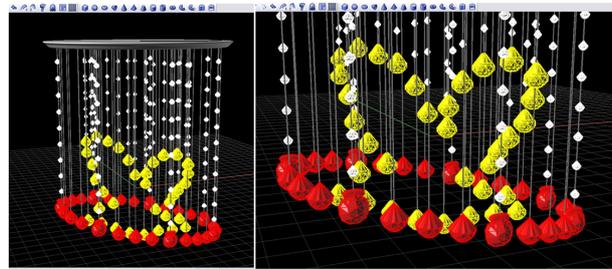


Fig.13 Complete 3D model of crystal lamps

## Conclusion

This research analyzes the structural characteristics of the crystal lamps, and they are divided into liner distribution, plane structure and 3D stricture. For the crystal lamps of linear distribution, a parameter modeling plug-in applicable to the auxiliary design of crystal lamps is developed based on Rhinoceros platform, which can free the designers from the heavy modeling process, through parameter selection and variable assignment, the design plug-in automatically completes the creation of crystal lamp 3D model, achieves parameter modeling and improves efficiency. Besides, it is of convenient modification and can determine the position of crystal monomer more rapidly and accurately, thus omitting the complicated calculation process of designers.

Due to the complicated and changing morphology of crystal lamps, the parameter plug in for the auxiliary design of crustal lamps developed in this research cannot be applicable to the crystal lamps of all modeling. In the next, deep research will be conducted on the calculation method of size and zooming proportion of crystal monomers.

## Acknowledgements

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