

# One-Click Quotation System and Method for Online Customization of Door Furniture

Fumin Xin\*, Shujuan Ding

Guangzhou Snimay Home Collection Co.,Ltd.,Guangzhou 510000, China

\* Corresponding author: Fumin Xin (Email: 401980802@qq.com)

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**Abstract:** Aiming at the problems of complex wiring, significant voltage drop, uneven brightness and insufficient intelligent adjustment of low-voltage LED lamps in customized home scenes, this paper proposes a customized home lighting adaptive adjustment management method based on artificial intelligence and big data, and designs a complete implementation system. The system takes the user's house decoration map and the lamp belt installation parameters as input, constructs the lighting demand analysis model and the lamp belt wiring optimization model, and completes the lighting strength area determination, converter number optimization and installation position planning through the artificial intelligence algorithm. Under the premise of significantly reducing the influence of voltage drop, the number of converters used is minimized. In addition, the system is also equipped with an environment-aware sensor, and a periodic closed-loop brightness adjustment algorithm is used to achieve adaptive matching of light brightness and illumination in different scenarios. The simulation results show that the proposed method can improve the brightness uniformity of the lamp belt by 28.7 %, reduce the number of converter configurations by 32.4 % on average, and the adaptive adjustment response time is less than 0.6 s. It can effectively solve the pain points of low-voltage lamp belt engineering application and improve the intelligence and practicability of customized home lighting system.

**Keywords:** Artificial intelligence, Customized home, Low voltage lamp belt, Wiring optimization, Illumination adaptive.

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## 1. Introduction

With the rapid development of smart home and whole house customization industry, users' demand for personalized, scene-based and intelligent home lighting continues to increase [1, 2]. The lighting control system also plays a key role in modern architecture and smart home [3]. It can significantly improve the comfort and practicality of the space, and users can flexibly create an ideal atmosphere by adjusting the brightness, color temperature and opening time, and according to different scenarios and needs [4, 5]. Due to its safety, reliability, soft light color and easy installation, low-voltage LED light belt is widely used in the interior lighting and atmosphere construction of customized homes such as wardrobes, cupboards and closets. However, the low-voltage lamp belt has the inherent defects of low power supply voltage (5V/12V/24V) and prominent voltage drop problem during long-distance transmission, which is prone to end brightness attenuation and uneven brightness. At the same time, the traditional wiring relies on manual experience, the converter configuration is redundant, the layout is unreasonable, the installation complexity is high, and the cost is high. The existing lighting control system mostly focuses on switching and color light adjustment, and lacks the integrated wiring planning and adaptive dimming ability for customized household structure and lamp belt installation constraints. It is difficult to take into account the lighting effect, installation cost and use experience [6, 7]. To this end, in view of the existing problems of the above low-voltage light belt, this paper proposes a low-voltage light belt light adaptive adjustment management method and system for customized homes by combining artificial intelligence, big data analysis and lighting control theory. By constructing the

lighting demand analysis model, the intelligent determination of the strong and weak areas of lighting is realized. The optimization model of the lamp belt wiring is established to complete the optimal planning of the number and position of the converter. The periodic sampling closed-loop adjustment algorithm is designed to realize the adaptive dimming of the environment. From the three dimensions of wiring design, voltage drop suppression and intelligent adjustment, the application problems of customized home low-voltage lamp belt are solved, which provides an engineering technical solution for smart home lighting system.

## 2. System Composition

The custom home lighting adaptive adjustment management system based on artificial intelligence designed in this paper consists of four core modules. The data flow between the modules is transmitted in one direction and works together. The structure is shown in Figure 1.

### 2.1. Customized home data acquisition module

It includes the collection unit of house decoration drawing and the data extraction unit of lamp belt, completes the conversion from unstructured house drawing to structured installation data, and outputs key parameters such as position coordinates, total length and installation path of lamp belt.

### 2.2. Lighting requirement analysis module

It includes historical big data unit and lighting demand analysis unit. Based on the training of massive house-lighting-illumination data, the lighting demand intensity discrimination model is constructed to realize the automatic marking of strong and weak areas of space lighting.

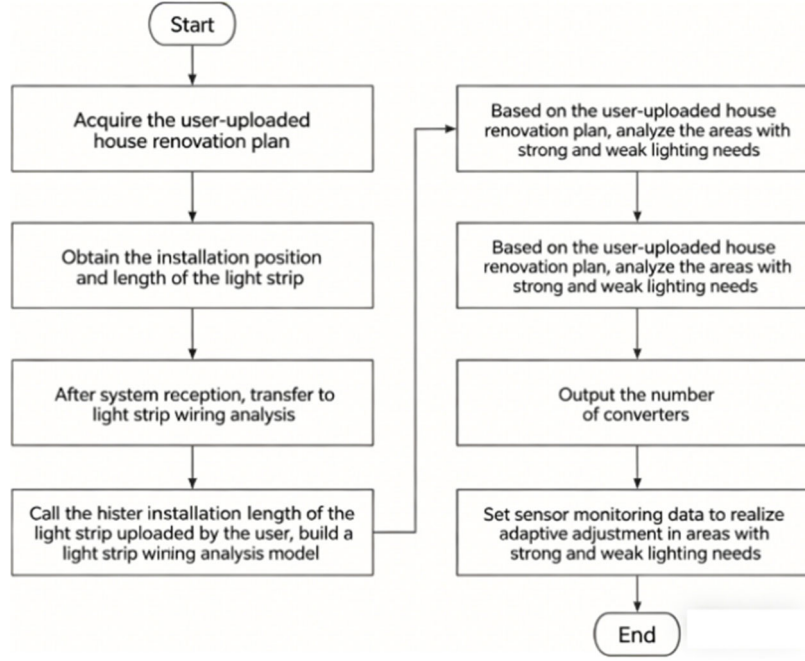


Figure 1. System composition structure

### 2.3. Artificial intelligence lamp wiring analysis module

It includes the lamp belt wiring analysis unit and the converter processing unit, and takes the voltage drop constraint, brightness uniformity constraint and cost constraint as the optimization objectives to complete the intelligent solution of the wiring scheme and the converter configuration.

### 2.4. Adaptive adjustment module

Integrating illumination sensor and human body sensor, periodic sampling-deviation calculation-closed-loop adjustment mechanism is adopted to realize differential adaptive dimming of illumination intensity area.

## 3. System Theoretical Model and Working Principle

### 3.1. Theoretical basis

#### 3.1.1. Sub-section Headings

The voltage drop of low voltage DC lamp meets Ohm 's law :

$$U = I \cdot R_{total} = I \cdot \rho \cdot \frac{L}{S} \quad (1)$$

Where,  $\Delta U$  is the voltage drop ;  $I$  is the loop current ;  $R_{total}$  is the total resistance of the wire ;  $\rho$  is the conductor resistivity ;  $L$  is the length of the wire ;  $S$  is the cross-sectional area of the wire.

The brightness and the terminal voltage approximately satisfy the linear relationship :

$$B = k \cdot U_{load} \quad (2)$$

$$U_{load} = U_{out} - \Delta U \quad (3)$$

Where,  $B$  is the brightness of the lamp,  $k$  is the brightness-voltage ratio coefficient.

#### 3.1.2. Lighting demand space analysis model

The three-dimensional rectangular coordinate system O-XYZ is established with the center of the house as the origin, and the discriminant characteristics of lighting demand are defined :

Area device distance  $D_{eq}$  : the distance from the edge of the weak light area to the nearest home device ;

Region position distance  $D_{pos}$  : the distance from the edge of the weak light region to the origin of the coordinate ;

Regional common degree distance  $D_{pass}$  : the distance from the edge of the low-light area to the indoor aisle.

Comprehensive characteristic value :

$$F = \omega_1 D_{eq} + \omega_2 D_{pos} + \omega_3 D_{pass} \quad (4)$$

Where,  $\omega_1$ ,  $\omega_2$ ,  $\omega_3$  are weighted coefficients, satisfying  $\omega_1 + \omega_2 + \omega_3 = 1$ .

#### 3.1.3. Multi-objective optimization model of lamp-belt wiring

Optimization objectives :

$$\min P = a_1 E_0 + a_2 S_0 \quad (5)$$

Constraint conditions :

$$\Delta U \leq U_{th}; E_0 \geq \left\lceil \frac{L_0}{L} \right\rceil; S_0 \geq 0 \quad (6)$$

Where,  $U_{th}$  is the allowable maximum voltage drop,  $L$  is the brightness stationary length,  $L_0$  is the total length of the lamp belt,  $E_0$  is the number of converters, and  $S_0$  is the area

of uncovered non-weak light area.

$$E = \left\lceil \frac{L_0}{L} \right\rceil + 1 \quad (11)$$

### 3.1.4. Adaptive brightness closed-loop adjustment model

Periodic sampling PI regulation is used to achieve fast tracking without static error :

$$u(t) = k_p e(t) + K_i \int_0^t e(\tau) d\tau \quad (7)$$

$$e(t) = B_{set} - B_{avg}(t) \quad (8)$$

Where,  $e(t)$  is the brightness deviation,  $u(t)$  is the adjustment of the output, to achieve fast tracking without static error.

## 3.2. System workflow

S1 Data acquisition and pre-processing

Obtain the decoration map of the house type, extract the installation position, length and path of the lamp belt, and establish the three-dimensional space coordinates.

S2 Lighting demand analysis

1. Historical big data is stored in sections according to the size of the house :

$$[N + (k - 1)M, N + kM], k = 1, 2, \dots, n \quad (9)$$

2. Calculate the comprehensive characteristic value F of the lamp belt area ;

3. Set the discriminant threshold U, if it meets

$$\frac{|2Y - T|}{2T} \leq U \quad (10)$$

It is marked as a weak illumination area ;

4. The region is merged and smoothed, and the illumination intensity partition map is output.

S3 Artificial intelligence wiring optimization

1. Calculate the brightness stationary length  $L$  ;

2. Number of initial converters :

3. Ergodic  $E_o = 1, 2, \dots, E$ , Solve the optimal installation position to minimize the uncovered area  $S_o$ ;

4. According to the objective function P, the optimal routing and converter configuration scheme is output.

S4 Adaptive brightness adjustment

1. Users set the expected brightness  $B_{set}$ ;

2. The average brightness of the periodic sampling environment  $B_{avg}$ ;

3. The closed loop adjusts the output PWM duty cycle to maintain the brightness stability;

4. Implement differentiated dimming strategy for strong and weak lighting areas.

## 4. Theoretical Model Simulation and Result Analysis

### 4.1. Simulation Environment

Simulating tool : MATLAB R2023b + Simulink.

Lamp belt parameters : 5V low-voltage LED light band, single meter power 5W, brightness stable length  $L = 3m$ .

Unit type parameters : 120m<sup>2</sup> three rooms two halls, the total length of the light belt  $L_0 = 24m$ .

Constraint conditions : Allow voltage drop  $U_{th} \leq 0.5V$ , weight  $a_1 = 0.6, a_2 = 0.4$ .

### 4.2. Simulation scheme

1. Voltage drop and brightness uniformity simulation: compare the end brightness attenuation of traditional wiring and optimized wiring;

2. Converter configuration optimization simulation: compare the number difference between manual configuration and AI optimization configuration;

3. Adaptive adjustment response performance simulation: test the adjustment response time and steady-state error.

### 4.3. Simulation results

#### 4.3.1. Brightness uniformity comparison

**Table 1.** Brightness uniformity comparison results

Scheme	Starting brightness (%)	End brightness (%)	Brightness uniformity	Brightness attenuation rate
Traditional manual wiring	100	68.2	76.5%	31.8%
The optimization scheme of this paper	100	95.3	95.1%	4.7%

Results : After optimization, the brightness uniformity was increased by 28.7%, and the effect of voltage drop was significantly suppressed.

#### 4.3.2. Comparison of converter configuration quantity

**Table 2.** Comparison of converter configuration quantity

Scheme	Number of converters	Installation cost	Routing complexity
Traditional manual configuration	9	High	Complex
AI optimization configuration	6	A lower	Simple

Results : The average number of converters was reduced by 32.4%, and the cost and construction difficulty were significantly reduced.

#### 4.3.3. Adaptively adjusts response performance

1. Adjust the response time : 0.48s

2. Steady-state brightness error :  $\leq 2.1\%$

3. Stabilization time of periodic sampling :  $\leq 1.2s$

Meet the real-time and stability requirements of home lighting.

#### 4.4. Analysis of simulation results

The simulation verifies that the lighting demand analysis model, wiring multi-objective optimization model and adaptive closed-loop adjustment model proposed in this paper are effective and feasible. They are superior to the traditional manual scheme in brightness uniformity, equipment configuration cost and system response speed, and can directly support the engineering application of customized home low-voltage light strips.

### 5. Conclusion

Aiming at the pain points of low-voltage LED light band voltage drop, unreasonable wiring and low intelligence in customized home scenes, this paper proposes a lighting adaptive adjustment management method based on artificial intelligence and big data, and completes system design and theoretical modeling. The main results are as follows :

1.The spatial analysis model of lighting demand is established to realize the intelligent discrimination of lighting strong and weak areas based on the household structure, which provides the basis for differential dimming;

2.The multi-objective wiring optimization model of low-voltage lamp is constructed, and the optimal wiring and configuration planning is realized with the constraints of voltage drop, number of converters and lighting coverage, which can effectively alleviate the problem of long-distance voltage drop and reduce the installation cost;

3.The periodic sampling PI adaptive brightness adjustment model is designed to realize real-time compensation of ambient light and fast and stable dimming;

4.The MATLAB simulation results show that the brightness uniformity of the system is improved by 28.7 %, the number of converters is reduced by 32.4 %, the adjustment response time is less than 0.5s, and the comprehensive

performance is better than the traditional scheme.

Future research will further integrate human body sensing, scene mode, voice control, expand color temperature and color adaptive adjustment, and combine edge computing to achieve local lightweight deployment, so as to promote the development of customized home lighting in the direction of more intelligence, energy saving and humanization.

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