Application of Fuzzy Logic Model for Correct Lighting in Computer Aided Interior Design Areas

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APPLICATION OF FUZZY LOGIC MODEL FOR CORRECT LIGHTING IN COMPUTER AIDED INTERIOR DESIGN AREAS.

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Abstract. Proper lighting is one of the important things in architectural design areas. Designers use a variety of software to design the interior of any area (eg AutoCAD, 3DsMax, SketchUp, Revit, etc.). Typically, designers determine the location lighting system and the number of bulbs prepared by the program. Problems arise when the design space provided by the designer is properly illuminated. To avoid these problems, it is necessary to pay attention to the following.

1. LUX definition by location
2. Calculation of reflection coefficients according to color tones.
3. Identification of chandeliers and lamps
4. Calculation of light flow (Lumen)
5. Calculation of bright intensity
6. Calculation of the room index
7. Lighting account

This article explores how to properly and efficiently illuminate daylight and artificial illumination in the interior design of 3Ds MAX according to a fuzzy logic model based on color tones. Based on the values obtained, calculations were made in the Fuzzy Toolbox section of Matlab and the results were obtained with lighting suitable for the interior design developed by 3DsMax.

Keywords: Fuzzy logic, Lighting, Daylighting, Color, İnterior design, CAD, 3DsMax

1. Introduction

As is known, light is a form of energy that affects our eyes and creates a sense of vision. This energy is defined by the theories developed by two independent conceptions.

- Light sources are classified in different systems in various publications. Light sources in terms of light production are as follows.
- Primary light sources; are objects that can emit light on their own (sun, candle, incandescent lamp, etc.)
- Secondary light sources; they are objects that emit light by reflecting or passing the light they receive from primary light sources, (moon, atmosphere, window, wall surface, etc.) Another classification is made according to the geometric shapes of the light sources;
- Point light sources,
- Linear light sources,

- They are listed as superficial light sources.

When light sources are classified according to the source of light;

- Natural light sources, sun, sky, windows, etc.
- Artificial light sources, candle, incandescent lamp, etc. We see that it meets in two main groups.
- The eyes' eyesight increases (visual acuity, eyesight increases).
- Eye health is protected, visual impairments are prevented.
- As the visual performance will increase, the efficiency of the work will increase, thus providing economic benefits.
- Visual comfort is also provided in psychological terms. The beneficiary feels happier in his / her environment.
- Accidents that may arise from inability to see well or to be blind are reduced.
- A sense of security is provided.

Fig. 1. Sample lighting

1.1 Indoor lighting

1.1.1 Light Flux Definition

Luminous flux Lumen (lm); is the total amount of light that a light source gives in every direction. It is the part of the electrical energy supplied to the light source that turns into light energy. We can also say the efficiency of the armature used. The light flow is denoted by the letter i.

1.1.2 Definition of Luminous Intensity

The sum of the luminous flux per unit surface is called luminous intensity. It indicates the level of light given by a light source in every direction. The unit of luminous intensity is luxury.

1.2 Lighting types

1.2.1 Types of Lighting

- Natural Lighting: It can be defined as the lighting system designed to meet the visual comfort needs of daylight, the main source of which is the sun.
- Artificial Lighting: It can be defined as the lighting system designed to meet the visual comfort needs of the light produced from artificial light sources,
- Integrated Lighting: It can be defined as the lighting system in which light is used as a supplement in meeting the visual comfort requirements in cases where daylight is insufficient.
- In the classification according to the place of illumination, we see that lighting is handled in two types, we can see this classification in many sources written on this subject.
- Indoor Lighting: It deals with the lighting system of the interior spaces, separated from the external environment by various structural elements.
- Outdoor Lighting: Building outside the building is the subject of the illumination system of various sizes.

2. Calculation of indoor lighting

2.1 Lighting Account

Various data and calculations are used for correct lighting. The tables given to you here are in the form of sampling. With these data, you can make more specific applications. Illumination calculations and factors of a place are explained step by step below.

2.2 Reflection Coefficients of Important Substances

In the table below, the reflection coefficients of some materials according to their color status are given. You can use these coefficients in the calculation.

Table 1. Reflection coefficients of some materials and wall colors

Material	%	Wall Paints	%
Dark	0,10-0,20	Oak Light Color	0,25-0,35
Brown	0,60-0,70	Chipboard Cream Color	0,50-0,60
Light yellow	0,45-0,55	plaster	0,90
Light green	0,30-0,50	Anodized Aluminum	0,85
Light red	0,35-0,45	Concrete	0,10-0,50
Sky blue	0,70-0,90	Glass-Silver-Moon	0,85-0,90
White	0,45-0,55	Granite	0,20-0,25
Pink	0,40-0,60	White Marble	0,60-0,65
Light grey	0,20-0,30	Lime whitewash	0,40-0,45

Table 2. Room lighting efficiency according to k values μ

Ceiling	0.80				0.50				0.30	
Wall	0.50		0.30		0.50		0.30		0.10	0.30
Floor	0.30	0.10	0.30	0.10	0.30	0.10	0	0.10	0.10	0.10
room index $k = \frac{a * b}{h * (a + b)}$	Room lighting efficiency factor (μ)									
0.60	0.24	0.23	0.13	0.18	0.20	0.19	0.15	0.15	0.12	0.15
0.80	0.31	0.29	0.24	0.23	0.25	0.24	0.20	0.19	0.16	0.17
1.00	0.36	0.33	0.29	0.28	0.29	0.28	0.24	0.23	0.20	0.20
1.25	0.41	0.38	0.34	0.32	0.33	0.31	0.28	0.27	0.24	0.20
1.50	0.45	0.41	0.38	0.36	0.36	0.34	0.32	0.30	0.27	0.26
2.00	0.51	0.46	0.45	0.41	0.41	0.38	0.37	0.35	0.31	0.30
2.50	0.56	0.49	0.50	9.45	0.45	0.41	0.41	0.38	0.35	0.34
3.00	0.59	0.52	0.54	0.48	0.47	0.43	0.43	0.40	0.38	0.36
4.00	0.63	0.55	0.58	0.51	0.50	0.45	0.47	0.44	0.41	0.39
5.00	0.66	0.57	0.62	0.54	0.53	0.48	0.50	0.46	0.44	0.40

2.3 Lighting Account Formulas

k = room index

a = short edge length of the room

b = long edge of the room

H = height between armature and working surface

$$k = \frac{a*b}{H*(a+b)} \tag{1}$$

Using these values, the room index k value is calculated. When each luminaire is installed in place, the lamp is usually 20 to 60 cm below the ceiling. B type luminaires do not have a distance, but for example for chandeliers, rod length can be taken as 60 cm. The working plane is generally considered to be 70-80 cm from the table length. In the sitting plane, 50 - 60 cm can be considered.

3. Color temperature selection

In fact, the color temperature expressed as Kelvin has nothing to do with physical heat for the user. On the contrary, in summer time when the bright blue lights of the sun are effective, the color temperature of daylight is defined as cold white. We call it orange-yellow or amber-colored light, which is given by candlelight, as warm white. In artificial light sources, the color temperature is generally in the range of 2500 to 8500 kelvin degrees.

3.1 Warm white light (2500-3300 Kelvin)

Color temperatures of 2500 - 3300 kelvin are considered as "warm light". Red, orange, yellow and brown are generally earthy colors used in homes, warm light colors are suitable for these spaces. Warm light generally provides a softer, better vision and a comfortable atmosphere than bright cold light. For this, it is used in bedrooms and living areas.

3.2 Natural white light (4000-4500 Kelvin)

Although warm light is generally accepted in homes, some people may prefer natural white light. Natural white light is at 4000 - 4500 kelvin color temperature. Natural white light is preferred in environments decorated with green, white and blue tones. It is preferred in offices and home offices since it creates an energetic and refreshing mood for people and employees.

At the same time, light in the color temperature of 4000 - 4500 Kelvin supports us to see detail and makes it easier to see imperfections in objects. For this reason, the places where cleaning is important is beneficial for the lighting in the makeup rooms.

3.3 Cool white light (5000-6500 Kelvin)

Technically, 5000 - 6500 kelvin light is the degree of kelvin of summer sun. So with such a light, you imitate the sun in lighting. Due to the excess blue light in 6500 kelvin light, risk begins to occur for our eyes. For this reason, it is necessary not to stay in these environments for too long. In working environments, cool white light can increase work efficiency, it is used in offices, garages, jewelery stores, leather and shoe stores, in displaying silver objects, in sports areas, outside of residences.

It is known that psychologically warm white light feels one to two degrees higher in the ambient temperature. Accordingly, according to sales statistics, preferences for the warm white light in the northern countries and the cold white light increase as they approach the equator region. One final note, if you are having insomnia, do not prefer cool white light in the evening, even if you love it, be illuminated with warm white light.

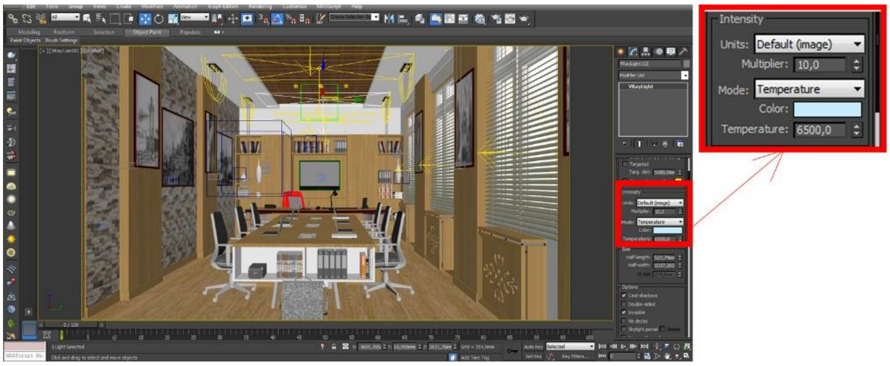

Fig. 2. Color temperature selection in 3ds max program

4. Fuzzy logic and lighting control

Daylight are a dynamic source of lighting and changes in daylight, season, location or latitude and cloudiness. Different levels of skylight can be found in the same sunlight, and even when the sky pattern remains, the range of solar lighting range of an instant turbidity filter or scatter is above the sun. As a result, the system must be flexible to allow any prediction multivariate system changes and skylight that characterize the combination of sunlight. In recent years, control technology has been well developed, and the vehicles in the most successful industry. However, due to the above mentioned aspects, traditional control systems, mathematical models, daylight energy management controls its limits. Taking into account the potentially existing random pattern, rapid change of daylight and artificial illumination properties, fuzzy control has proven to be a more suitable solution.[1]

In our case, taking into account the windows head height,the pattern of the daylight is presented in Fig. 3; accordingly, four control zones parallel to the short side of the room have been identified.

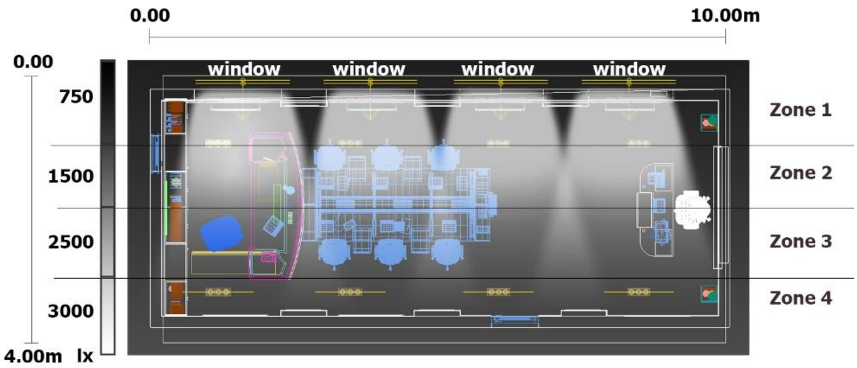

Fig 3. Daylighting of the room

5. Practical application of fuzzy technologies.

When both inputs and outputs are used with membership functions, the conventional expressions between them are constructed as follows: If (input UF x), then (output UF y). For example, "if the temperature is high, the value of success is very low" Figure 1. In the general approach, the model can have more than one input parameter and must be combined with AND, OR, NOT. Parameters and rules are unstable and can be changed under different conditions, which increases the use of the model. In a fuzzy process, each rule is evaluated to determine the output, and as a result, the Fuzzy Information System is the average of all outcomes. In this way, each design work is done to a certain extent, which shows that it is extremely successful in terms of time and quality. This value is in the range [0 8000]. When the process is complete, a list is created and can be used visually.

Every linguistic variable has five fuzzy values with triangular or trapezoid membership functions, as follows:

- For input variables – Fig 4: *VH*-veryhot; *H* – hot; *N* – natural; *C* – Cold ; *VC* – verycold
- For output variables – Fig 5: *VL* – very low; *L* – low; *M* – medium; *H* – high; *VH* – very high.

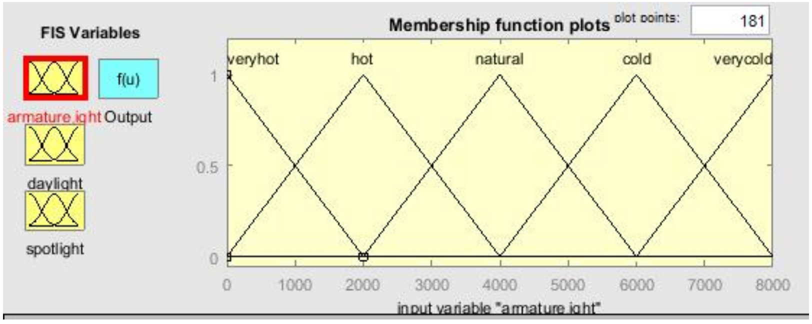

Fig 4. Input variables fuzzification

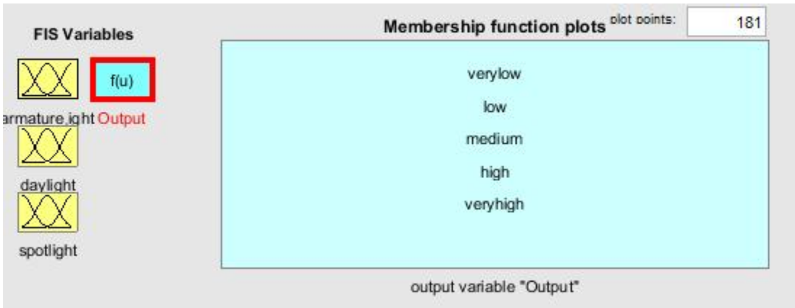

Fig 5. Fuzzification of output variables

The knowledge base used by the control system is given in Table 4, where μi (i = 1 ... 4) represents the membership functions corresponding to the four control zones.

Table 4. Membership functions

IF			**Then**			
A	**B**	**C**	**μ1**	**μ2**	**μ3**	**μ4**
VH	VH	VH	V H	V H	V H	V H
VH	VH	H	V H	V H	V H	V H
VH	VH	N	V H	V H	V H	V H
...	...	...	...	...	...	...
L	L	L	V L	V H	V L	V L

The processing stage invokes each appropriate rule and generates a result for each of them, then combines the results of the rules; this mechanism was implemented by the max-min inference method.

Conclusion

According to the results obtained by fuzzy logic, when preparing interior design in computer-aided design programs, special attention should be paid to the color temperature in order to obtain the correct lighting.

Thus, fuzzy control can be a better solution in light transmission, which can be an issue that can be easily expressed by mathematical modeling because the information is not available, is incomplete or very complex.

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