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Design of Intelligent Blind Control System to Save Lighting Energy and Prevent Glare

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Abstract. Glass walls for exterior building can help save energy as increase inflow of natural sunlight. However, when sunlight directly reaches on floor, it can be occurred reflection glare, and visual discomfort. A blind can be in charge of preventing glare, but over prevention of sunlight affects increase of lighting energy. In this paper, we propose intelligent blind control system using electric venetian blind, which consists of multiple slats, and can be controlled slat angle and heights to prevent glare and to save lighting energy. The proposed system controls slat angle and heights of blind according to altitude of sun. Also, the system guarantees brightness on the floor by additional compensation of slat angle and heights of blind according to brightness on the floor measured by luminance meter.

Keywords: blind control, venetian blind, glare, lighting energy saving

1 Introduction

It is known that a lighting energy inside the building through windows is decreased as the inflow of natural light is increased [1]. However, the direct sunlight into the room increases the brightness of the floor thereby can cause glare to the residents.

A blind is a device which is popularly installed in the windows or walls that are made of the glass in order to block the direct sunlight and makes some of the reflected light inflow into the room. Because the blind control decides the inflow of the natural light, affects directly on the lighting energy consumption, various researches about controlling the blind progress. [2] analyzed the energy saving effect by the roll shade blind by using a simulation tool. Energy saving was greatly achieved by the blind with high visible light penetration, confirmed that inflow of the natural light was an important factor to save the lighting energy. [3] analyzed the effect of slat angle of the venetian blind on the brightness of the indoor space by using a mockup model. However, these preceding studies carried out analyses by using mainly simulation tools, the practical experiments in the actual building environments could not be established.

In this paper we proposed an intelligent blind control system considered energy saving and glare prevention by using electric venetian blind with the adjustable height

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and slat angle. The proposed system intelligently controlled the height and slat angle according to the altitude of the sun and brightness of the floor surface, saved the lighting energy by utilizing inflow of the natural light, thereby prevented glare caused by high brightness of the floor surface.

2 Intelligent Blind Control System

2.1 System Architecture

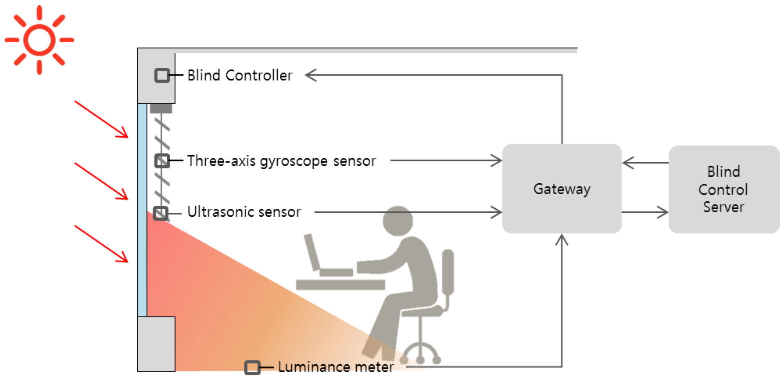

Fig. 1. Overall architecture

Figure 1 shows overall architecture of the intelligent blind control system proposed in this paper. The proposed system is constructed with the blind controllers, ultrasonic sensors, three-axis gyroscope sensors, luminance meters, gateways, and blind control server. The blind controller adjusted the angle and height of the slat with an electric motor. The ultrasonic sensor and three-axis gyroscope sensor measure the opening height of the blind and the slat angle, and send the data to the blind control server for accurate control of the blind. The luminance meter measures brightness of the floor and sends it to the blind control server. All the sensors and controllers are connected with the blind control server through the gateway.

2.2 Blind Control Procedure

Figure 2 shows the blind control procedure of the proposed system. The blind control server calculated the altitude of the sun based on the date, time, latitude, and longitude set blind control server. Equation (1) is used to calculate the latitude of the sun [4].

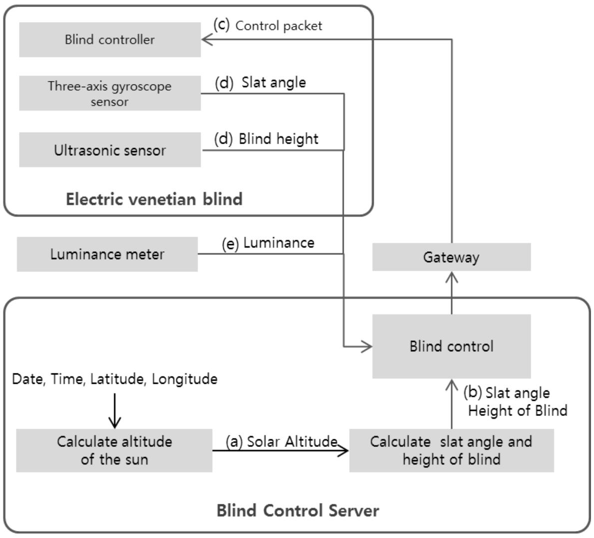

Fig. 2. Blind control procedure

In the equation (1), θs is the altitude of the sun, L is the latitude of the point to be measured, δ is the declination of the sun, and ω is the hour angle of the sun. Once the altitude of the sun is determined, the blind control server calculates the optimum slat angle and blind height that can block direct sunlight. Equation (2) and equation (3) are used to calculate the slat angle and height of the blind, respectively.

$$\theta_s = sin^{-1}(\sin L \sin \delta + \cos L \cos \delta \cos \omega) \quad (1)$$

$$\alpha = sin^{-1}(cos\theta \times \frac{w}{s} - \theta) \quad (2)$$

$$\beta = \rho \tan\theta - \sigma \quad (3)$$

In the equation (2) and equation (3), α is the slat angle, θ is the incidence angle of the sunlight inside a building, w is the width of the slat, s is the gap between the slats, β is the height of the blind, ρ is the distance between the blind and the floor, and σ is the height of the blind from the floor. After calculating the height and slat angle of the blind, the blind control server sends commands to blind controller. For accurate control, ultrasonic sensor measures the height of the blind, and three-axis gyroscope sensor measures the slat angle. Once the blind control is completed, luminance meter measures brightness of floor to prevent floor. If the brightness of the floor exceeds a specified range, a calibration process is executed by changing the slat angle and height of the blind by stages so that the brightness of the floor is maintained as a standard level.

Figure 3 shows the blind compensation procedure to prevent glare. When the blind control server receives luminance data from luminance meter, if the data is greater than luminance threshold, the blind control server executes compensation procedure.

L_v: Luminance measured by luminance meter
L_t: Luminance threshold to prevent glare
α: Slat angle
β:Heighte of Blind
ε: Control step
n: Step counter

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while (Lv > Lt)
        α ← α + ε · (-1)^n · n
        if minimum slat angle > α or maximum slat angle < α then:
                calculate slat angle using equation (2)
                β ← β – 1
                n ← 0
        end if
        n ← n + 1
```

Fig. 3. Blind compensation procedure

3 Conclusion

In this paper, an intelligent blind control system is proposed to maximize the inflow of the natural light and to prevent glare by the direct sunlight to the occupants while saving the lighting energy under the building environment wherein venetian blinds are installed. The proposed system controls the slat angle and height of the blind according to the altitude of the sun. Further, a mode of calibration of blind is proposed so that the brightness of the floor would not exceed a specified level. In the future, practical experiment and analysis are required to investigate the energy saving and if the glare is prevented by the proposed system.

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