A Kinetic Light Shelf Unit as an Integrated Intelligent Control Device for Optimizing Interior Illumination

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***Abstract* - This study suggests a Kinetic Light Shelf Unit (KLSU) which is possible to change the function intelligently according to information for the altitude of the Sun. When the Sun's altitude is high, the kinetic shelf unit works as the light shelf that can improve the interior illumination. Also, when the Sun goes down, the kinetic shelf unit operates as the vertical louver which blocks the direct rays of the Sun.**

Keywords - Kinetic Building Facade; Light Shelf Unit; KLSU; Optimized Louver; Integrated Intelligent Control Device

I. INTRODUCTION

Nowadays, building energy management is more important than ever. Especially, lighting energy used in the building occupies 30% of the whole consumed energy. This amount increases continuously. [1] Therefore, the solution to reduce the energy consumption is needed in these days. If appropriate method for providing of daylight in interior spaces was applied, it would help in energy saving. Light shelf is well known as the eco- friendly lighting technology. Furthermore, building design including light shelf is acceptable for the Leadership in Energy & Environmental Design (LEED).

The light shelf system has two major functions; it can reflect light deeper into interior space and block the direct light as well. When the reflected light on light shelf comes into the deeper interior space, the lighting energy will be decreased during a day time. Moreover, the solar radiation will be blocked by the light shelf as a shading device. These two functions are deeply related to the use of energy. [2]

For this reason, this proposed device is considered as a promising and practical skill. But this device is significantly affected by the altitude and motion of the sun, so it may have a limitation about the range of use. Accordingly, the purpose of this study aims at suggesting a kinetic light shelf makes the functions to be formed according to the altitude of the sun.

II. KINETIC LIGHT SHELF UNIT

A. State of the art

A light shelf is an architectural technology that makes light to penetrate deeper into the inner space. Figure 1 that shows light shelf is reflecting the light. This reflected light reduces the needed energy for artificial lighting to keep on acceptable indoor illumination in buildings.

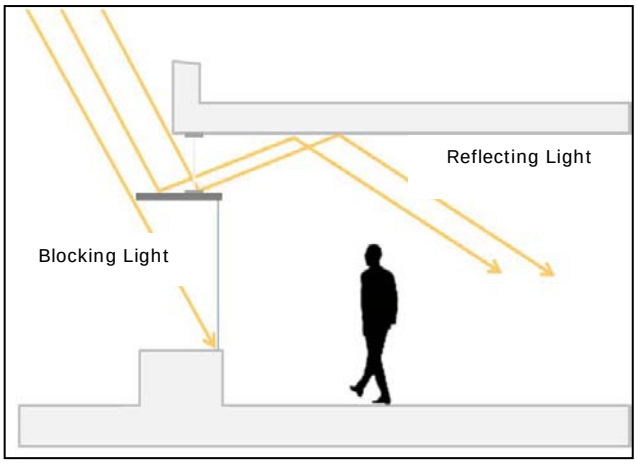

Figure 1. Concept and Function of the Light Shelf

The second function of the light shelf is to block the direct solar radiation that considered the major factor of heat gain inside indoor spaces. [3] Hence, the cost of keeping the indoor environment comfortable is going to decrease.

B. Limitation of the light shelf associated with the altitude of the Sun

In oder to the function shown by 'Figure 1', the position of the sun should be located between AM 11 and PM 1 (See Figure 2). This is because the light generated from the higher

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altitude of the sun can be reflected by light shelf. [4] But when the sun set down into the ground, this function of light shelf will become dwindle. [5] And the sunlight that penetrate window will have an impact on the indoor environment.

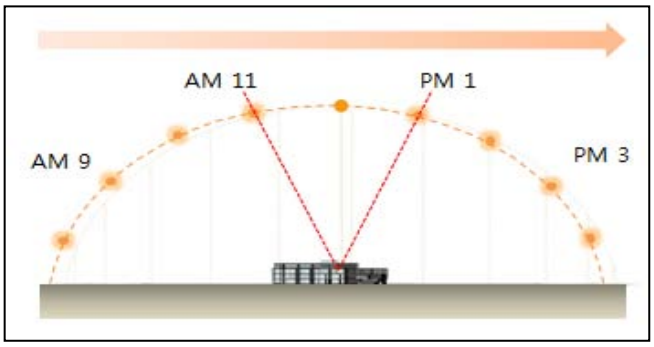


Figure 2. Performance Section of Light Shelf

C. Concept of the Kinetic light shelf which can adapt to altitude of the Sun

The most important feature of the KLSU is possible to adjust in the altitude of the sun. When the sun is located between a and b including meridian transit altitude (lower-left corner), KLSU works as a light shelf. Through this a to b course, indoor space can get the natural light reflected by surface of the light shelf.

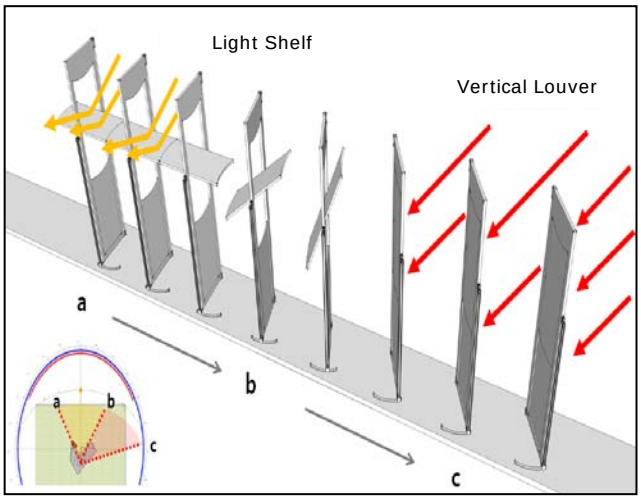
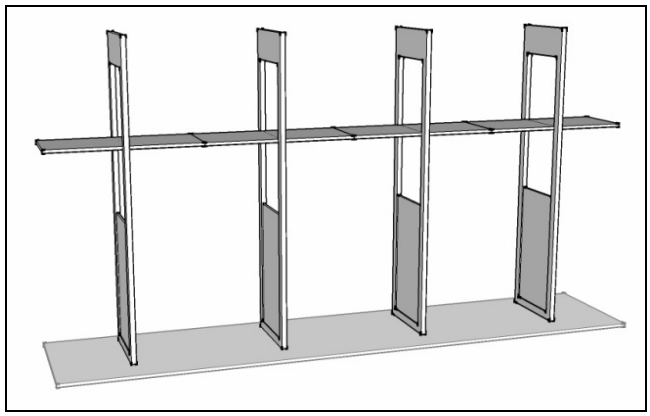


Figure 3. Conversion Process of KLSU

The surface of the shelf is covered with high reflectivity material. And when the sun is located between b and c (red part, lower-left corner), KLSU operates as a vertical louver to block out the direct light. Two types of the function are shown by Figure 3 which represents the changing course from horizontal (light shelf) to vertical (louver). Like this, KLSU can be changed light shelf into vertical louver and it works to fit in each situation.

D. Design process of KLSU

In this part, we have looked at the first step of the KLSU design. First, a main frame that contains a light shelf is designed as a modular. So it can be installed to match the scale of the building. [6] [7] Design process Ⅱ shows the course about removing conflict parts.



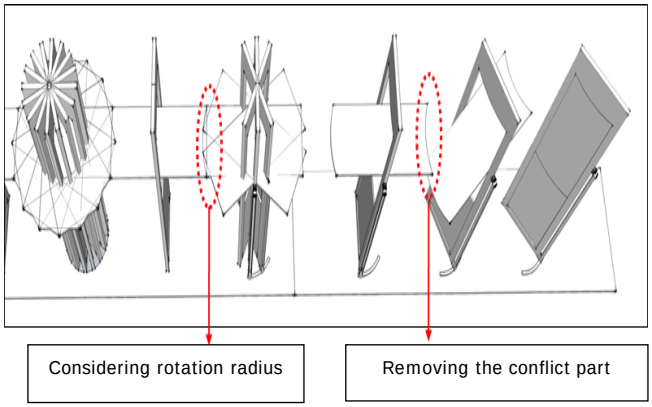


Figure 4. Design Process Ⅰ (up) and Ⅱ (down)

When connected KLSU elements are moved along the rotation rail, the edge of the shelf conflicts each other (Red dotted line). Thus the shelf design is decided by this process.

E. System components and operating steps

1) System components

In this part, it shows that components of the KLSU and operation steps. Consists of following elements (See Figure 5). 1st is main frame fixed to the axis of rotation. 2nd is the

light shelf reflecting the light. 3rd is the circle rod that penetrate the center of the shelf, so it makes possible to change horizontal into vertical.

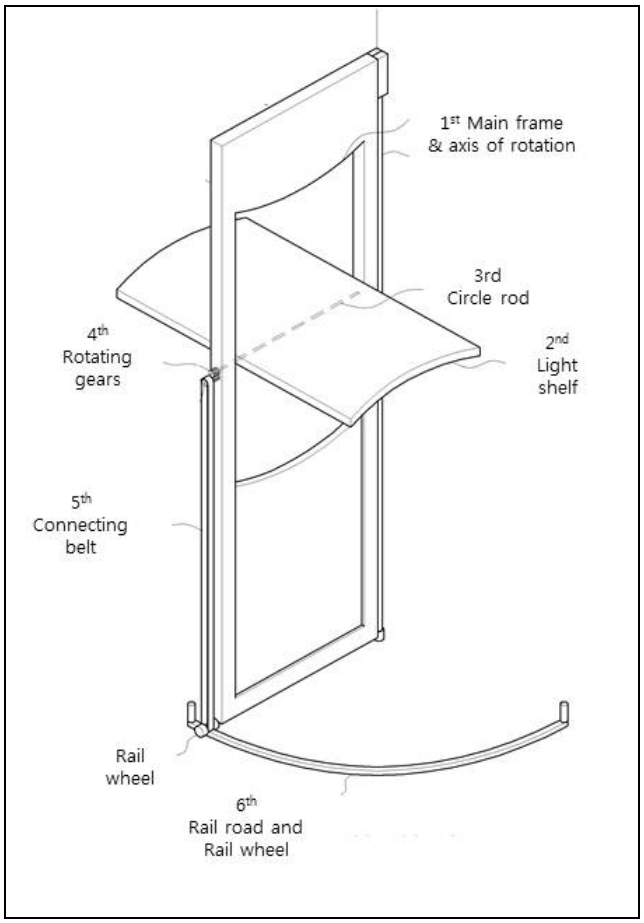


Figure 5. Components of a KLSU

4th through 6th are the key of this mechanism. 4th is rotating gears which are connected each other and one is bonded to the end of the rod. 5th is connecting belt that connect the gear with the rail wheel. 6th is the rail frame and rail wheel; the main frame is moved along this rail line around the axis.

2) Operating steps (from horizontal to vertical)

Step 1) KLSU works as the light shelf; Step 2) Rail wheel moves along the rail road; Step 3) Connecting belt is operated by the rail wheel; Step 4) Light shelf is turned into a vertical position by the movement of the gear that is affected by belt.

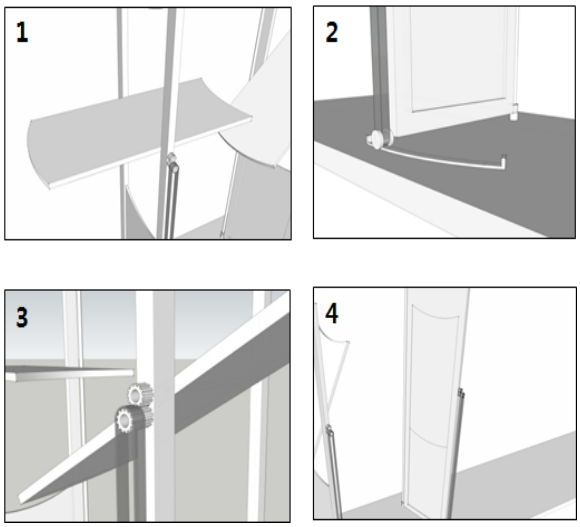


Figure 6. Operating Process

In sum, the suggested intelligent light shelf unit has been successfully responsible to the altitude of the sun, and the following is the flowchart showing a series of procedures towards its optimized functionality.

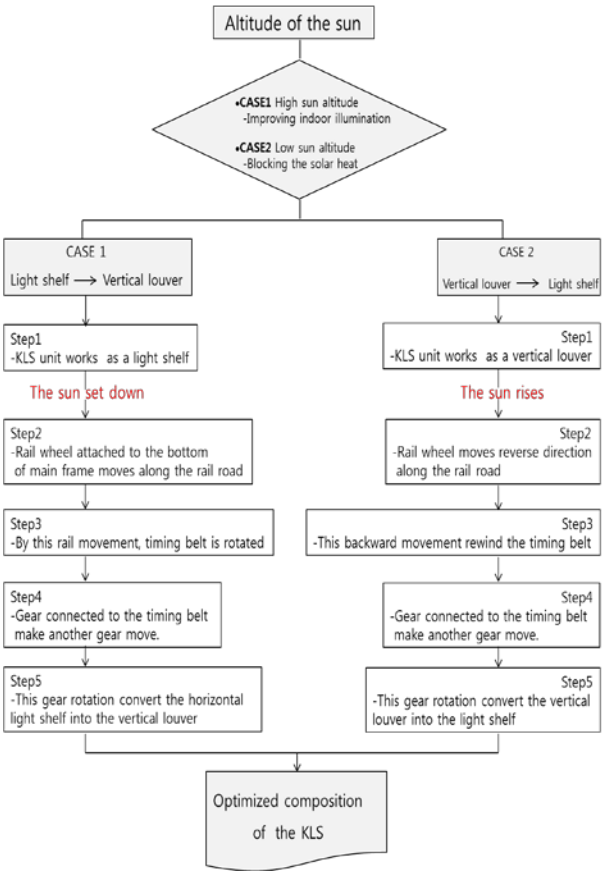


Figure 7. Flowchart of the Optimizing Process

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KLSU proposed through this paper has been testified by multiple simulations such as Project Vasari and Autodesk Ecotect with Desktop Radiance and its adaptability remains as ongoing issue for future studies.

III. CONCLUSION

Through this study, KLSU was introduced. This system is a new mechanism that is operated by interlocking main frame and light shelf. So, the kinetic shelf unit works as the light shelf and the kinetic shelf unit also operates as the vertical louver when the sun goes down. Based on this study, next research will proceed about the energy efficiency as well as the functional elements by using scale model.

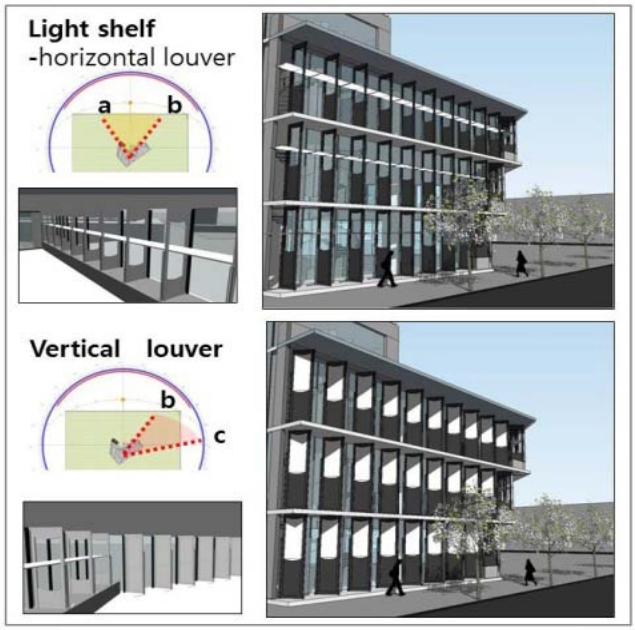

Figure 8. Application to the Building Façade

It will focus on the solar energy accumulation method associated with the altitude. The effect of variation in façade also can be offered in aspect of design. The kinetic façade changing from horizontal to vertical gives rise to the value such as building cognition. Advantages in all things will increase the possibility of eco-friendly technology.

ACKNOWLEDGMENT

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