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Clock Light Design Based on Sunrise and Sunset Time

Abstract
We intend to develop a clock with a natural human perception of time, instead of a numerical one. Our representation of time was inspired by the difference in light during sunrise and sunset depending on the season or place and its annual recurrence. The events of sunrise, midday, and sunset, which consist our time series, was appointed a specific color based on the theory associated with color temperature, and connected with gradation. To be able to show the time information with light, we created a physical form. This clock light functions as an indirect light source and gives emotional value to time.

Keywords: clock, lighting design, emotional design

1 Introduction
Time is between two specific points of time. While numerical time is a moment, time itself is a continuum.[1] In nature, time doesn’t have specific borderlines but moves on continuously. It is also closely related to the human biological cycle. Human beings studied how to measure time through history and as we progressed through the ages, it has become more quantified. Still, humans most naturally recognize time through the noticeable changes in sunrise and sunset. It is because the changes in daylight, caused by the sun, grants us visibility of time. Light is an immaterial entity. When light manifests itself, it interacts with material, form, and other various conditions, and creates, in formative aspects, a new visual image and intensifies the visual effect.[2] Light conditions, beams of light, etc., manifested on an object not only makes the object visible to the human perception but more directly affects the human senses.[3] Therefore, through the experience of providing a new visual image, presenting the concept and information of time with light can be regarded as a human-centered emotional design.

This research expresses time with light. Time is represented in and around sunrise, sunset, and day length instead of numbers. Through this clock design prototype, we intend to provide an emotional experience for the user by visualizing time that repeats and changes fluidly throughout the year.

The process of this design research is as follows:
1. Research sunrise and sunset information to represent time with light. This was in order to find a fluid pattern in light that changes depending on the region in an annual cycle.
2. Appoint colors to light that represent time information. The fundamental colors were chosen based on borrowed and expanded concepts of ecological and healing
light in emotional lighting designs. A time display method was devised for intuitive recognition of time flowing while best representing the properties of the light.

3. Design a physical form to display time. Composed various sketches considering that embodying light produces different feelings depending on the physical form. Technical realization was done through Arduino, Wi-Fi shield module, and Open API linking of sunrise and sunset data.

2 Time manifested through light and color

The meaning of time is polysemous and multidimensional by nature. Dividing a day in 24 hours and assigning 12 hours each to night and day is a result of today’s widespread cultural practices. Hesiod, while writing a chronicle regarding human activities, saw that the true nature of time is in the constant dialogue between nature and culture.

Nature is phenomenons that are linked to each other. Hesiod saw that human activities utilizing time is a better way to understand time measurement rather than a date. Although this kind of ecological time is periodic, it was impossible to express it as a circulation due to its complexity. So all communities that ever made a clock had to simplify it, using the sun and the moon and the average of their cycles.

Through these processes, the concept of time became simplified and standardized, and became logical in characteristic. However, the human perception of time is still deeply associated with biorhythms, while it also builds a daily rhythm. Humans start the day when the sun rises and finishes work when it gets dark. The change of light during a day as time goes on, caused by the sun, is at the heart of this biological activity cycle.

2.1 Expressing daylight with color gradation (Fig.1)

The appointed colors, changing with the passage of daytime, were based on color temperature. In related research, there is a concept of emotional lighting that humanity has evolved to adapt to the natural light. There are also claims that the human body and mind react sensitively to various lighting environments that are more comfortable and work efficiently within lighting environments similar to the natural light. There are also claims that the human body and mind react sensitively to various lighting environments that are more comfortable and work efficiently within lighting environments similar to the natural light. There are also claims that the human body and mind react sensitively to various lighting environments that are more comfortable and work efficiently within lighting environments similar to the natural light.

2.2 Sunset and sunrise time data

We researched about sunset and sunrise to link the color of light with time data. Fig 2 (below) is an example of a chart that shows Seoul, Republic of Korea and Oslo, Norway have different annual intervals of sunrise and sunset. The vertical axis shows the time of day and the chart as a whole shows sunrise and sunset intervals centered on daytime. The time interval of sunrise, sunset, the length of day, and nighttime expressed in previously derived color gradation is below. Table 1 shows color gradation, expanded and based on the light concept of emotional lighting. It shows the flow of changing light as time passes in a day.

The changes in color gradation also shows difference depending on the length of the daytime per location. Depending on the location, light is represented differently even during the same time of the day. These differences, as shown in Fig 2, form a unique shape for each region and repeat annually. The left column of the bottom chart is a daily sun graph of Republic of Korea, Norway, and Argentina showing the time of sunrise, sunset, and the length of daytime on August 2nd, 2016. When this is expressed by the gradation of previously found colors, it will look like the right column of the bottom chart. This clearly shows that different colors may show even in the same time of the day.

Table. 1 The length of daytime according to sunset and sunrise and corresponding color gradation of Norway, Republic of Korea, and Argentina.
3. Clock light design prototype

We designed a clock to display the time information based on the color changing light and the investigated information above. We attempted to find the most harmonious combination of physical form, light and color so it has an emotional function as an indirect light source in the user’s life as well as being able to check the time.

3.1 Time display and clock design

To comprehend time information, a method to recognize the hour and minute is necessary. The short needle representing the hour was replaced with a small circle. Beginning at 12AM and 12PM, it comes to one full circle. The minutes, the long needle of an analog clock, was placed at the larger circle. To differentiate the color gradation of minute from the similar color gradation of hour, the minute display flashes every second to show time passing. Also, to differentiate the same AM and PM time, a different color was used for the AM and PM.

![Fig. 3 Time display and design of physical form](image)

![Fig. 4 The user’s daily life and the changing clock light](image)
3.2 Usage scenarios and utilization
Clock indicating time with light can give time information to the user as well as function as an indirect light source. Fig 4 shows a possible scenario of a user’s day and how the colored light shows depending on the time.

1. The clock light brightens up as the sun rises. It changes to the color of sunrise, orange (R252,G173,B30), and the light becomes brighter as the alarm that is linked to the user’s mobile phone ring.
2. During midday, when the sun crosses the meridian, the light changes to the color blue (R15,G100,B249).
3. Afternoon, as time goes on to nightfall, the light changes color to red (R230,G10,B19), the color of the sky during sunset.
4. At night, the light becomes a violet (R175,G212,B233) color, and by sensing the main light source darkening, at the user’s time of sleep, the light of the clock becomes fainter.

In addition, the clock light can be used as an indirect light source at night, instead of a clock, depending on the user’s setting. The user may choose a color of the light to utilize its light therapy function to improve physical condition and recover from fatigue.

3.3 Technical realization method
For the design prototype of the clock, Arduino is combined with a Wi-Fi module (Wiz fi 250) to receive sunrise and sunset time. The time can be changed to match various regions and time zones through Open API[10] related to the sunrise and sunset time. While the main body uses Arduino, by using Color Pixel LED for embodying light, color (RGB 0~255) and brightness can be controlled. Lastly, Real Time Clock Module was used to calculate the clock error range for the accuracy of time.

Fig.7 API linked Arduino program and used mechanical parts

4. Conclusion
Light has meaning as a tool for expressing emotional information. To receive a day’s sunset and sunrise information and expressing it as time is not a fixed or repetitive movement like the existing clock. Showing cycles of different colors depending on the region and the subtle change of colors in light create a different emotional experience. The goal of this research was to develop an idea using the sunrise and sunset time data. Henceforward, we intend to develop this towards synchronizing individual time data (personal schedule, alarm, etc.) to express more meaning of the user’s time, through a mobile application.

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