

# AugmentedBacklight: Expansion of LCD Backlights Using Lighting Methods in the Real World

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**Abstract.** People experience various lights in daily life, such as sunlight through leaves and candle light. However, digital contents shown in common LCDs cannot express these impressive lights. In this paper, we propose a novel display technique, AugmentedBacklight, which can express impressive lights in the real world by expanding the LCD backlight. The system mainly consists of a transparent LCD, a screen behind the LCD, and a projector behind the above devices. The projector shows videos of impressive lights on the screen for the backlight of the transparent LCD. Thus, users can see digital contents (e.g., e-books and pictures) under various impressive lights in the real world.

**Keywords:** Display, backlight, lighting.

## 1 Introduction

People experience various lights in daily life, such as sunlight through leaves, candle light, and sun glare on water. These lights affect appearances of objects in the real world. For example, people often feel different impressions by reading books under sunlight through leaves compared to under fluorescent lamps. However, digital contents shown in common LCDs cannot express these impressive lights since the LCD backlight emits flat lights –same brightness in each pixel – to keep visibility. To overcome this limitation, we propose a novel display technique, AugmentedBacklight, which can express impressive lights in the real world by expanding the LCD backlight.

## 2 Related Works

Seetzen et al. [5] and Chen et al. [1] proposed novel displays that have similar mechanisms with our system: that is, integrating a transparent LCD and a DLP projector/LED-based display to expand the LCD backlight. Suyama et al. [6] proposed a Depth-fused 3D (DFD) display that enables a user to perceive an apparent 3D image using overlaid two displays. Lee et al. [4] proposed a unique DFD display that integrates fog screen and two projectors.

While these systems focused on expanding dynamic ranges of pictures/videos shown on the LCD or generating 3-D image, our system focuses on expressing appearances of contents under various impressive lights in the real world.

There were several art works [2, 3] that add visual effects to real time videos depending on activities of people in the real world. Our system may effectively work in such applications.

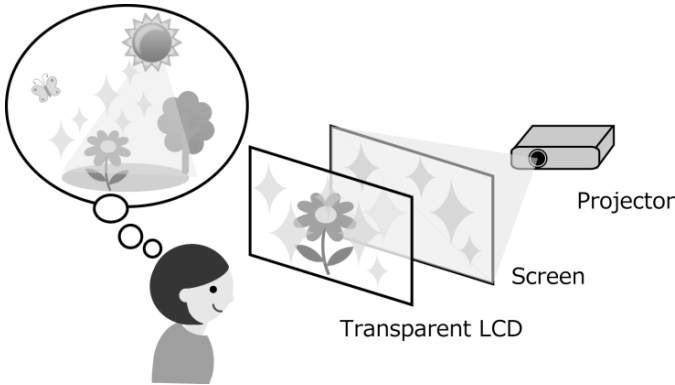


Fig. 1. Basic concept of AugmentedBacklight

### 3 AugmentedBacklight

The basic concept of AugmentedBacklight is to express various lights in the real world by expanding the LCD backlight (Fig. 1). Many lights in the real world (e.g., sunlight and spot lights) have so high luminance that most people have difficulty to look at them directly. These lights also have fluctuation depending on surrounding environment (e.g., sunlight reflected on the water). In this research, we aim to express these lights on the LCD using lighting video that includes impressive lights in the real world. For example, our system may recreate an experience of reading a book under sunlight through leaves by integrating texts and the video of such lighting.

The system mainly consists of a transparent LCD, a screen behind the LCD, and a projector behind the above devices. As shown in Fig. 1, the projector shows videos of impressive lights on the screen for the backlight of the transparent LCD. Thus, users can see digital contents (e.g., e-books and pictures) under various impressive lights in the real world.

#### 3.1 Prototype

We developed a prototype as shown in Fig. 2. It consists of a projector (EPSON EB-410W, 2000lm), a transparent LCD (TCR-3104M) and a screen (handmade acrylic panel). The LCD and the projector are connected to a PC (Windows XP) via an USB-VGA convertor (Buffalo, GXDVI/ U2AI) and a built-in VGA connector.

The main program running on the PC controls (1) videos of impressive lights shown on the screen through the projector and (2) main contents (e.g., e- books, pictures or web pages) on the LCD. In this paper, we defined the prior contents as “light contents” and the later contents as “main contents”. Since impressive lights in the real world (e.g., sunlight through leaves) often change their brightness and textures dynamically, we selected videos of such changing lights as the light contents.

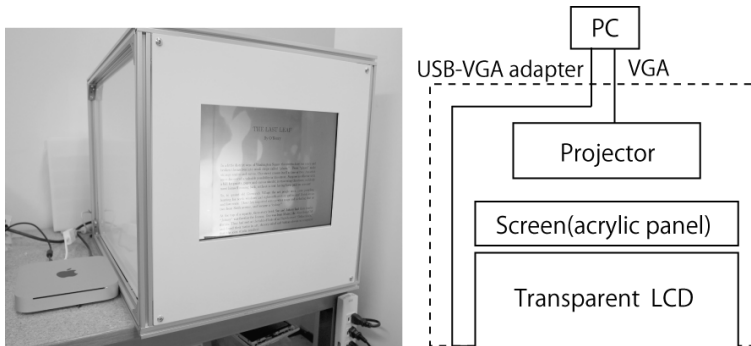


Fig. 2. The AugmentedBacklight prototype

### 3.2 Design of Light Contents

We selected light contents in consideration that users can perceive impressive lights on the display without bothered by uncomfortable feelings. In this paper, we focused on mainly two categories: (A) impressive lights in the real world, and (B) impressive visual effects created by computer graphics. The former category includes videos of sunlight through leaves thrown on the wall and sunlight reflected on water. The latter category includes visual effects of lightning and brilliant lights. These examples of light contents are shown in Fig. 3. These contents are converted into gray scale to avoid affecting colors of main contents.

### 3.3 Design of Main Contents

We selected still images as main contents to verify the basic performance of light contents. For example, we prepared pictures of “green leaves”, “a flower”, “lake” and “texts in an e-book” in corresponding to the impressive lights in the real world. We also prepared pictures of “people” and “a glass besides the window” suited for the visual effects. These examples of main contents are shown in Fig. 4.

## 4 Preliminary Study

We performed a preliminary study to verify the basic performance of the AugmentedBacklight prototype. We have selected 5 subjects (3 females, aged between 23 and 33) from our laboratory.

### 4.1 Procedure

We explain basic procedure of the preliminary evaluation. First, we set each subject down in front of the AugmentedBacklight prototype and explained the basic function of the system. Next, the experimenter shows a main content along with the white background instead of a light content. Then, the light contents are changed several times. After the subject repeated these processes for all main contents, the experimenter ask them to write the impression of the system.

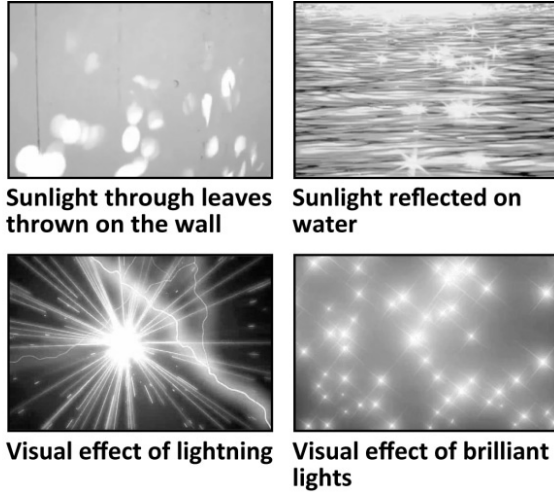


Fig. 3. Examples of light contents

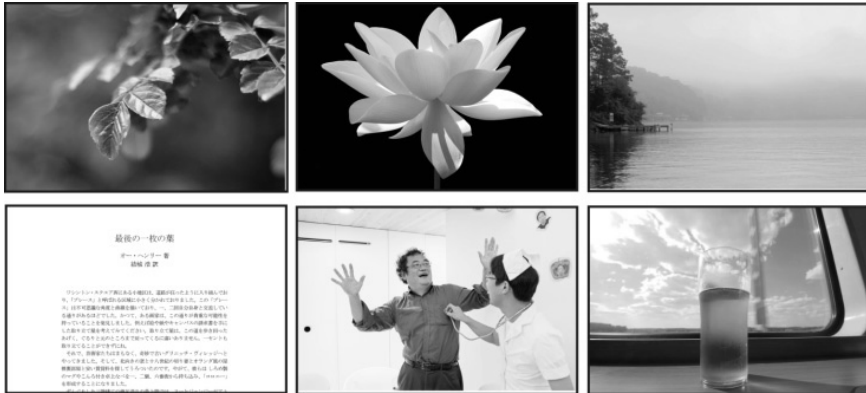


Fig. 4. Examples of main contents

### 4.2 Results

In this section we explain the results from the viewpoints of “effective examples” and “findings”.

### Effective Examples

First, we describe effective combinations of light contents and main contents. The picture of each combination is taken with a digital camera (GR Digital 2) at a close range.

Fig. 5 shows the combination of “green leaves” and “sunlight through leaves”. The typical impressions written by the subjects were as follows:

- The green leaves look vivid by the movement of sunlight through leaves.
- Beautiful. The backlight looks actual sunlight through leaves.



**Fig. 5.** The combination of “green leaves” and “sunlight through leaves”

Fig. 6 shows the combination of “texts in the e-book” and “sunlight through leaves”. The typical impressions written by the subjects were as follows:

- The gentle movement of the sunlight brought me comfort.
- I can read texts more easily than I imagined.

Fig. 7 shows the combination of “surprised person” and “lightning effect”. The impressions of the subjects were as follows:

- Strange feeling. The person and other objects look floating on the air.
- Cool. The person seems to emit the aura.
- I felt retro impression like old films or stained glasses.

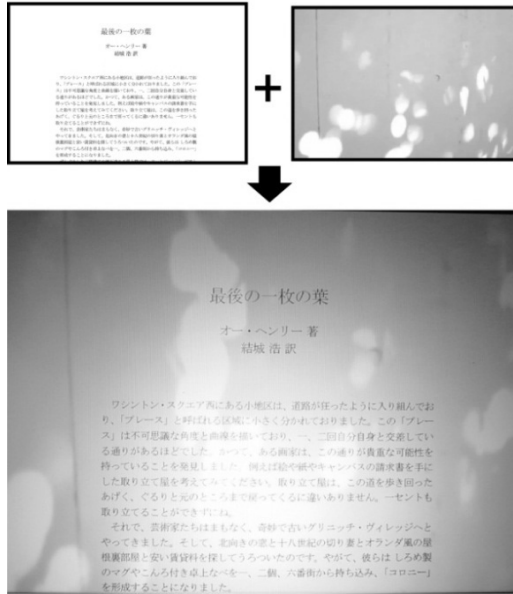


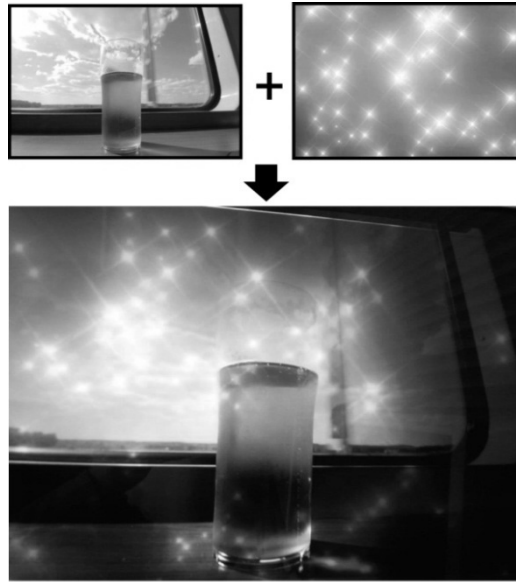
Fig. 6. The combination of “texts in e-book” and “sunlight through leaves”



Fig. 7. The combination of “surprised person” and “lightning effect”

Fig. 8 shows the combination of “a glass besides a window” and “brilliant lights”. The impressions of the subjects were as follows:

- The picture looks like a 3D image. It seems to pop out from the display.
- I was interested in the effect since I have never seen such lighting in the real world.



**Fig. 8.** The combination of “a glass besides a window” and “brilliant lights”

### Findings

All subjects reported that the pictures shown with the light contents look different from ones with the white background. Some subjects felt the depth between light contents and main contents. Others reported each main contents looks drastically different depending on light contents.

Since most subjects felt the stereo effect in the picture of “a glass besides a window” in which the main object is simply located on the center, the light contents may effectively works with pictures that have simple compositions.

As the combination of light/main contents, most subjects had comfort with the combination of contents in similar situations. For example, “green leaves” and “sunlight through leaves” as shown in Fig. 5 are one of the most popular examples in the preliminary evaluation. On the other hand, some light contents (e.g., “sunlight through leaves”) work rather effectively with variety of main contents. For example, a subject mentioned “I would like to use the light content (sunlight through leaves) as the background of my desktop”.

Meanwhile, visual effects (e.g., lightening and brilliant lights) were not suited for simple main contents (e.g., texts in e-book) since these effects have too strong presence that most subjects have difficulty to read texts with them. However, when the main contents are carefully selected, the visual effects may give great impacts on users as shown in Fig. 7.

In this study, we confirmed some effective examples of contents for the AugmentedBacklight. We would explore people’s impressions on various combinations of light/main contents more accurately. Moreover, we also try to specify the cognitive factor that affects unique experiences with our system.

## 5 Conclusion

In this paper, we proposed a novel display technique, “AugmentedBacklight”, which can express impressive lights in the real world by expanding the LCD backlight. We have developed a prototype system using a transparent LCD, a screen behind the LCD, and a projector behind the above devices. We introduced the examples of light contents shown on the screen through the projector and main contents shown on the LCD. We also explained the effective examples through the preliminary evaluation.

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