Solar Projector

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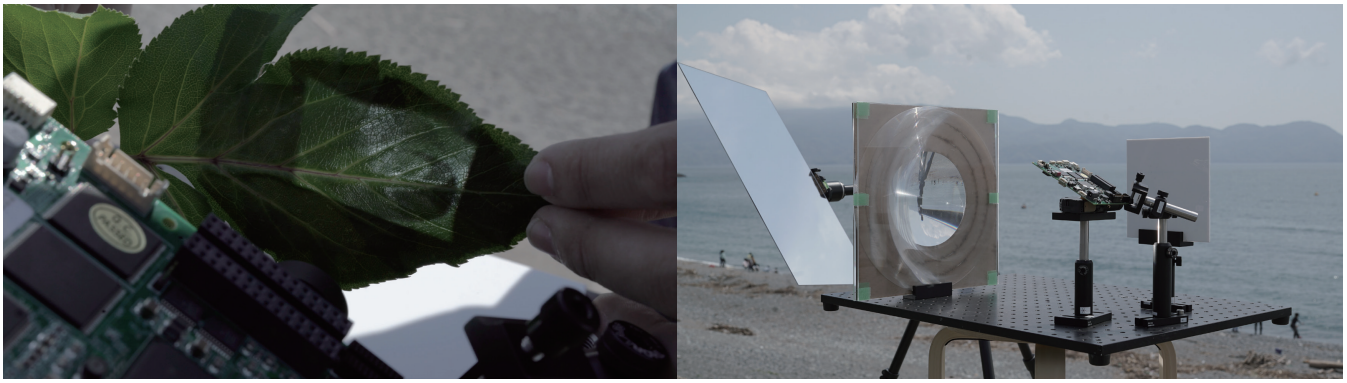

Figure 1: Left: As an example of application, we show how projection was performed on plants. Right: Projection setup. It consists of a mirror that reflects sunlight for the first time, a lens for condensing light, and a projector.

CCS CONCEPTS

• **Hardware** → *Displays and imagers*;

KEYWORDS

projector, sunlight

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1 INTRODUCTION

The sun is the most universal, powerful and familiar energy available on the planet. Every organism and plant has evolved over the years, corresponding to the energy brought by the sun. Humanity is no exception. We have invented many artificial lights since Edison invented light bulbs. In recent years, LEDs are one of the most representative examples. Displays and projectors using LEDs are still being actively developed. However, it is difficult to reproduce ideal light with high brightness and wide wavelength like sunlight. Furthermore, considering low energy sustainability and environmental contamination in the manufacturing process, artificial light can not surpass the sunlight. Against this backdrop, projects that utilize sunlight have been actively carried out in the world. Concentrating Solar Power (CSP) generate electricity using the heat of sunlight to turn turbines [Müller-Steinhagen and Trieb 2004]. [Koizumi 2017] is an aerial image presentation system using the sun as a light source. Digital sundials use the shadow of sunlight to inform digital time [Scharstein et al. 1996]. These projects attempt to use the direct sunlight without any conversion and minimize the energy loss.

In this paper, we propose an image projection system using sunlight as a light source (Fig. 1). Specifically, Digital Mirror Device (DMD) reflects concentrated sunlight and projects images with natural light. In this way, it became possible to project images using light in a wide wavelength range that can not be reproduced by LEDs. By directly utilizing sunlight, it is possible to realize new projection harmonious with nature, such as applying it to photosynthesis of plants.

2 IMPLEMENTATION

We propose a projector that uses sunlight as a light source and makes the projected contents variable with DMD (Fig. 2). First of all, in order to use sunlight as a light source, it is necessary to converge the sunlight into the optical path. The reason why sunlight is condensed is that if it is tried to use sunlight without condensing, the optical circuit must be enlarged in order to collect necessary energy. If it is necessary to enlarge the optical circuit in proportion to the necessary amount of light, the scalability as a projector is lost.

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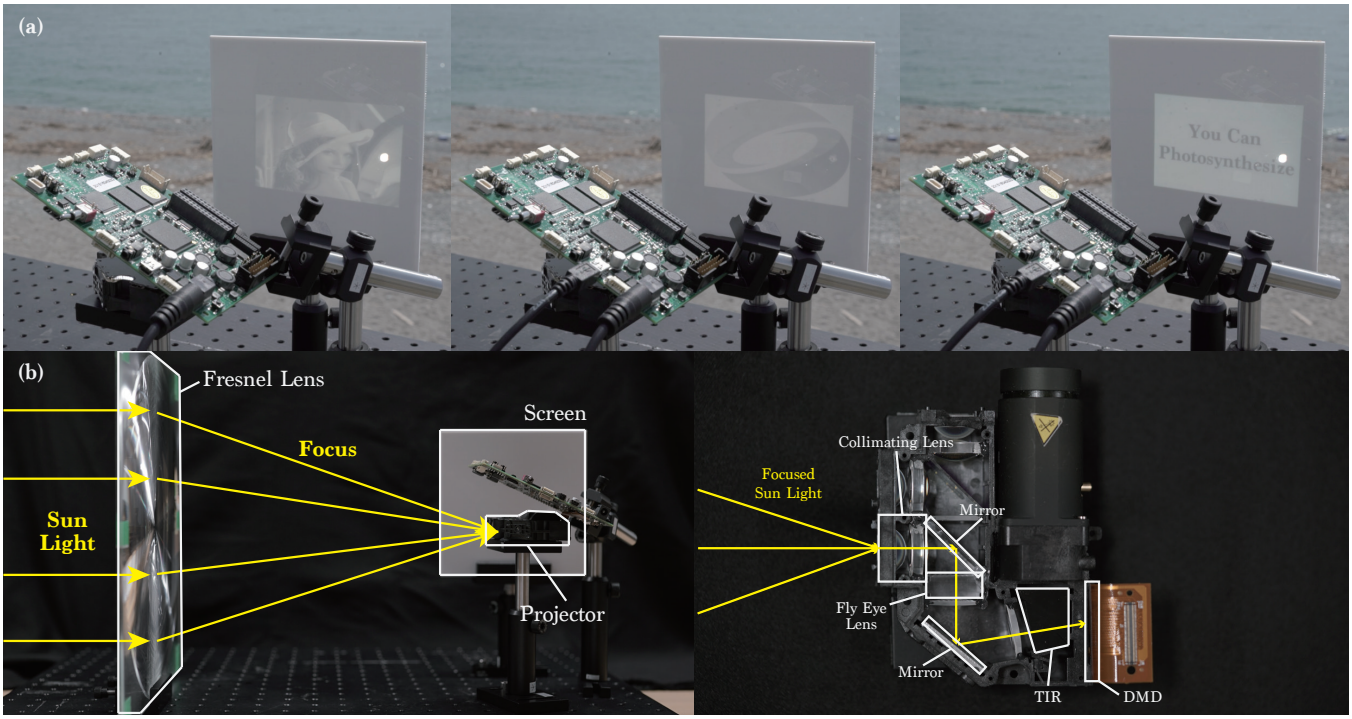

Figure 2: (a) Examples of the projection of three kinds of images. (b) Detailed view of the optical circuit. The figure on the left of (b) shows how the light is focused on the projector part. The figure on the right of (b) shows how the collected sunlight passes through the projector.

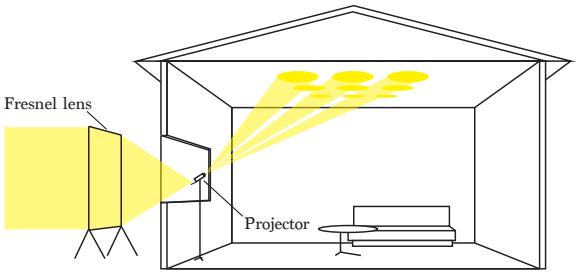

Figure 3: An application using sunlight in the house.

By concentrating, it is sufficient to scale only the light condensing unit in accordance with the light quantity. Therefore, sunlight is reflected by a mirror and made incident on a Fresnel lens, so that light is focused.

Next, an optical circuit for suitably hitting the incident light to the DMD is described. The condensed light passes through the collimating lens and is homogenized with a fly's eye lens. Total Internal Reflection Prism (TIR Prism) is used to simultaneously irradiate the DMD and secure the optical path to the projection circuit. Finally, the screen is placed in a position so as to be parallel to the projection lens so that the state of projection can be ascertained.

3 DISPLAY RESULT

In Fig. 2, we show how three projected images are projected on the screen using this projector. 8 bit grayscale image is projected at 100 fps using DMD. Sony α7RII was used as a camera. The ISO sensitivity was fixed at 100, the shutter speed was set to 1/125 s, and the F value was fixed at 16. Moreover, the state of the sun during shooting was clear and the ambient light was also bright enough.

4 DISCUSSION

Since this projector is only a prototype, there are several aspects that we would like to improve. Firstly, as we use sunlight, we need to implement a function that keeps converging according to the movement of the sun if it is to be used for a long time. Next, since the amount of heat becomes extremely high at the time of condensation, the amount of light to be collected must be within the range of the thermal durability of the lens. In the future, our system can be used for lighting utilizing sunlight in the house (Fig. 3).

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