Edible Lens Array: Dishes with lens-shaped jellies that change their appearance depending on the viewpoint

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ABSTRACT

This study presents food products whose appearance, such as color and image, changes depending on the viewpoint. This was achieved by fabricating jelly with structures of convex lenses, which is arranged in a two-dimensional plane using 3D-printed molds. This enables interactive gastronomic experiences with the presentation from multiple viewpoints. In this study, we developed a system that supports the design and fabrication workflow for edible lens arrays. Using our system, users can design arbitrary lens array shapes and simulate their appearance based on the refractive index of the jelly material. The system then outputs a 3D mold model for casting the jelly lenses. In addition, we created several dishes that exhibit viewpoint-dependent changes in appearance, demonstrating their potential for creating interactive gastronomic experiences.

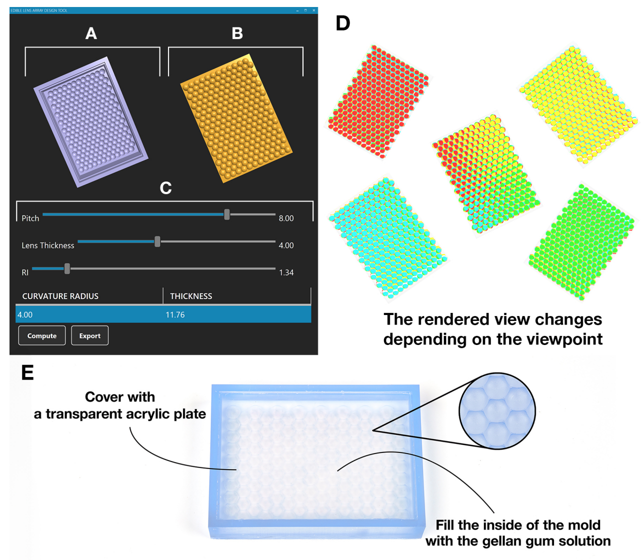

Figure 1: (A–D) Illustration of Design Software, (E) Molding the gellan gum solution using the designed mold.

CCS CONCEPTS

• **Human-centered computing** → *Human computer interaction (HCI).*

KEYWORDS

Edible Optics, Lens Array, Lenticular Lens, Digital Food Fabrication, 3D Printing

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1 INTRODUCTION

Molecular gastronomy is an area of scientific analysis and research on food ingredients. In this area, scientific knowledge across physics and chemistry is applied to cooking to develop advanced cooking methods and expand the expression of cooking [1]. Tokyo's French restaurant "élan vital" explores new and unprecedented ways of expressing food through molecular gastronomy, projection mapping, and fabrication technology [2]. Since 2022, we have been collaborating with "élan vital", proposing the "Edible Lenticular Lens" as a food with unprecedented visual effects and have been developing dishes using this technology [3]. In the previous study, we redesigned the shape of a lenticular lens, which is an optical element that changes appearance depending on the viewing angle, using jelly material [4, 5]. We then fabricated the lens using a 3D-printed mold. However, edible lenticular lenses are one-dimensional lens arrays, allowing image changes only in one direction. By overcoming this limitation and enabling changes from a wider variety of viewpoints, we can create a gastronomic experience where the performance is generated from a specific viewpoint can be created. This increases the degree of freedom in the design of gastronomic experiences using edible lenses.

In this study, we propose an edible lens array made of jelly to create dishes with changing appearances from multiple viewpoints. A lens array is an optical element consisting of a large number of tiny lens elements [6], and the shape proposed in this study consists of convex lenses arranged in a two-dimensional plane. Combined with the underlying image pattern, this enables image changes in a two-dimensional direction according to the viewpoint.

In addition, we developed a system for chefs to design and fabricate arbitrarily shaped edible lens arrays. Users can design arbitrary lens arrays using the design software within the system and confirm their appearance through simulations. Furthermore, users can 3D print the mold models output by the system and mold the lenses

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using a mold-forming method. This study presents three examples of dishes that use edible lens arrays.

2 SYSTEM

Design Software. The design software was created in Rhinoceros/ Grasshopper and its plug-ins, Human UI and V-ray for Rhino. The interface shown in Fig.1 (A–C) enables users to input parameters including pitch, curvature radius (lens thickness), and Refractive Index (RI) to obtain a 3D model of a lens array with arbitrary specifications. Reducing the thickness of the lens section increases the curvature radius and widens the viewing angle of a single image through the lens array. The user can control image switching and viewing by adjusting the curvature radius. To adapt to various edible materials, the RI parameters were implemented in addition to lens shape parameters, such as pitch and curvature radius. The input parameters were used to calculate the optimized lens array thickness using the lens maker's formula. This tool allows users without specialized knowledge of optics to design lens arrays with appropriate visual effects. The compute button enables the users to execute the parameter changes. The export button exported the mold with the inverse structure of the designed lens. During the design process, users can also preview and modify the visual effect through a ray-tracing simulation in real time, as shown in Fig.1 (D).

Lens Array Fabrication. The mold was 3D-printed using an Stereolithography (SLA) 3D printer (Form 3B+, Formlabs). It is composed of biocompatible resin (BioMed Clear Resin, Formlabs). Because the proposed mold-forming method 3D prints the model output from the system, the maximum size that can be formed depends on the 3D printer used. In Fig.1 (E), the size of the mold was 3R (127 mm × 89 mm). The jelly used to fabricate the edible lens arrays was prepared using 3 g of SOSA's gellan gum as the solute and 450 g of Suntory's Yogurina as the solvent, as described in a previous study [4]. The RI was approximately 1.34 as measured using a digital refractometer (HI96801, HANNA). In addition to this recipe, the application illustrated in Fig.2 (C) used 35 g of Ina Foods' Ina Agar as the solute and 600 g of Coca-Cola's I LOHAS flavored with shine muscat as the solvent. The image patterns beneath the lens arrays were created using an image compositing program developed in Processing. By inputting images and the pitch of the lens array, an image corresponding to the designed lens array is output.

3 APPLICATIONS

Here, we introduce three culinary examples to demonstrate the potential for new gastronomic experiences made possible by dishes that change their appearance depending on viewpoints. For an image pattern placed at the bottom of the lens array, the prototype in Fig.2 (AB) was made on a photo paper, whereas the one in Fig.2 (C) was printed on a ceramic plate using the Porcelarts technology. This application caused no problems with food safety and hygiene.

To demonstrate the effect of the image change, we created a dish in which the painting varied according to the perspective of the viewer (Fig.2 (A)). Designed to emulate a picture frame, this lens array salad surrounds a central jelly made using edible lens array technology and is framed by baby leaves and nuts. The appearance of the jelly changes between four famous paintings depending on the viewpoint: "Fine Wind, Clear Morning (Gaifu kaisei)", "The Great Wave off Kanagawa (Kanagawa oki-nami-ura)", "Mona Lisa" and "The Milkmaid". To achieve the image transformation, a considerable amount of information is required. Therefore, we used a lens array with a relatively high resolution (p (pitch) = 4.00 mm, r (curvature radius) = 2.00 mm, t (thickness) = 5.88 mm).

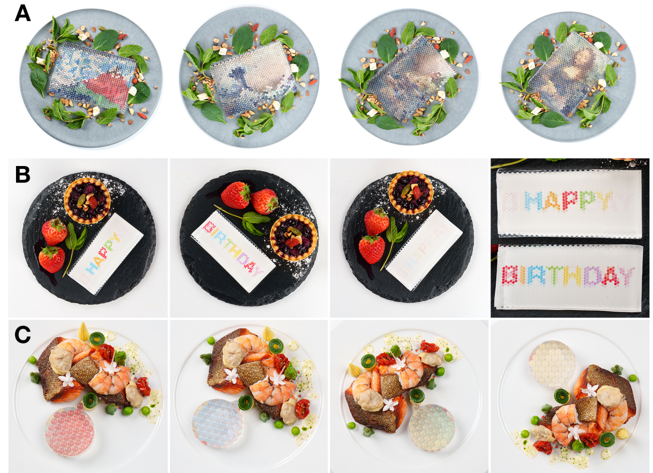

Figure 2: (A) The lens array salad with edible arts, (B) A dish with messages that can only be observed from specific viewpoints, (C) A dish developed in collaboration with élan vital.

To demonstrate the effect of the character change, we created a dish with messages that are visible only from specific viewpoints (Fig.2 (B)). This dish utilizes a jelly lens array for the message plate that conveys textual information, with strawberries and tarts are placed around the plate. From one viewpoint, the message "HAPPY" can be seen; from another viewpoint, the message "BIRTHDAY" is visible, and nothing is displayed from other viewpoints. A higher resolution is required to achieve the character transformation. Therefore, we used a lens array with the smallest pitch size (p = 2.00 mm, r = 1.44 mm, t = 4.23 mm) verified by the authors.

To demonstrate the effect of the color change, we created a dish that changes color depending on the viewpoint (Fig.2(C)). This dish was developed in collaboration with élan vital [2]. In this dish, a lens-array shaped circular jelly is combined with colorful ingredients, such as grilled salmon, shrimp, and salad, in a layout. We used a relatively large pitch size lens array (p = 8.00 mm, r = 4.00 mm, t = 11.76 mm) in terms of the balance of the food layout and the eating experience. The color of the circular jelly changes to red, blue, green, and yellow depending on the viewpoint, thus changing the atmosphere and color of the entire dish.

4 FUTURE WORK

In the future, we will develop a surface polishing method to reduce rough marks caused by 3D printing, evaluate the optical properties of lens arrays composed of several materials, and verify the number of viewpoints that can be achieved. Through these studies, we hope to improve the quality of the proposed technology and expand its application range.

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