An omnidirectional shape-changing bubble display

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Abstract: We present a novel spherical display that utilizes a bubble as a screen material. This device can quickly generate soap bubbles as the screen. Since the generated bubbles are initially transparent and fragile, we propose a technique such as rapid freezing to fix the bubble and enable image projection. In this paper, we propose the first prototyping method and some application ideas such as an instant spherical screen or remote presence display by taking advantage of the deformability and rapid generation/bursting capability of the bubble.

1. Introduction

The spherical display can display in all directions while allowing users to touch and interact. It will have completely different applications and interaction methods depending on the size and shape of itself. For example, when the display is small, it is suitable for a single user to browse and operate it with both hands [1], while a large spherical display can be used by multiple people to communicate with each other around it [2]. However, the shape and size of the traditional spherical display cannot be changed. The number of applications that can be realized on a single display is limited.

Therefore, we decided to propose a deformable spherical display, which can quickly change the size and shape of the display surface to adapt to more content and applications Figure 1. To make a deformable spherical screen, the material of the screen is the most important thing to consider. The material to form the sphere must be flexible, varying smoothly from flat to spherical, and could be fixed in any shape and size as needed. Also, the surface of the sphere should diffuse the projector light.

Therefore, this research proposes to use "bubble" as the screen. We believe that the bubble has the following advantages and potential. The bubble is flat before forming, and while it expands, it will go through a change from becoming hemispherical to spherical, which can freely switch between two-dimensional and three-dimensional and change the size of the display surface.

However, it is still difficult to use the bubble as a screen to project images from a projector because of its high transparency. This research first explores a method for dynamically controlling the transparency of sphere-shaped bubbles, such as ultrasonic, rapid cooling, etc. At the same time, it can also realize some unique interactions because of the rapid generation and bursting of bubbles. For example, the following "instant spherical screen" could be realized. Users can blow up the bubble on the projector lens when needed and instantly create a spherical display of any size and shape. When it is no longer needed, it can be immediately destroyed and returned to a normal projector.

In this research, we prototype a spherical bubble display platform with the unique capabilities described above, studying smooth video transitions between spherical displays of different sizes/shapes and input motions suitable for use on dynamic soap bubble screens. Besides, we propose applications that take advantage of bubbles to validate the unique interaction elements such as shape-changing and destructible omnidirectional projection, touch interaction, and artistic projection, etc which achieved by our system.

2. Related Work

The Poppable display [3] utilizes transparent soap bubbles as a projector light diffuser by vibrating it with ultrasonic waves. In this research, we will investigate the application of its method, and we will also consider the methods of cooling and freezing the soap bubble and chemically hardening the soap bubble. By hardening the soap bubble surface, we believe that it will be possible to interact by directly touching it, which has not been possible in previous studies.

Balloonygen [4] is a spherical display that can dynamically change shape by using rubber balloons. By controlling air pressure, Balloonygen can produce a spherical display of any size from a flat surface. Although this study is the previous research of our study, the most significant difference from our proposal is the transparency and renewability. The bubble used in our study is normally transparent, and the screen can be quickly eliminated and rebuilt by destroying and generating bubbles. Although transparency is a disadvantage of the screen, the projector can project forward as usual while the bubble is transparent or not yet inflated. We

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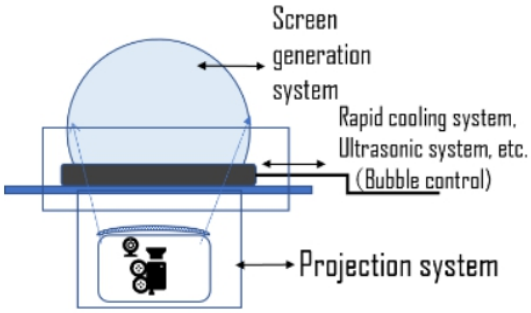

Fig. 1 Hardware configuration

develop a new interactive display that takes advantage of the dynamic change in transparency of the spherical screen and the immediacy of the creation and destruction of the bubble.

3. Proposal Method

This research focuses on the interactivity of the bubble and considers the properties of it, which can produce different interactions under different conditions. First of all, the primitive bubble has high deformability, but it cannot be projected because of the transparency and will break if touched. In this case, we consider using ultrasound to vibrate so that it can be projected. At the same time, users can also control the size of the bubbles and perform some simple interactions through specific items such as straws. Also, because it can be quickly generated and destroyed, users can use this feature as an input interaction.

Considering the interactivity brought by touch, we think it is necessary to make bubbles that can be touched. We propose to use freezing to make the soap bubbles hard and able to be projected. Under this condition, the size of the soap bubble will be fixed once it is generated, and it has a certain degree of hardness, allowing users to touch and interact with it. Besides, we also consider adding other ingredients to the soap liquid or using thermoplastic material as raw material to change the transparency or hardness of the generated bubbles. This method also has different interactions according to the different materials of the generated soap bubbles. In the prototype design, we will focus on freeze the bubble and the construction of the cooling system.

4. Prototype Design

The system configuration is shown in Figure 1. This system consists of three parts, namely the projection system, the screen generation system and the bubble control system. The projection system consists of a projector and a camera, and is responsible for detecting the shape generated by the screen system and performing omnidirectional projection. The bubble generation system is responsible for producing soap bubbles. Regarding the bubble control system, our research mainly proposes to study a rapid cooling system to harden the bubbles. The constitution of the cooling system is shown in Figure 2. We plan to use multiple peltier devices to celerity freeze the bubble so that it can be projected. The structure of the peltier device is shown in Figure 2.

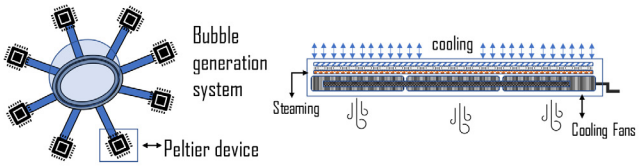

Fig. 2 Rapid cooling system and Peltier device

5. Application ideas

The proposed system can realize spherical screens of various sizes and shapes, and at the same time, it can be applied to the following applications that take advantage of the rapid "expansion", "hardening", and "destruction" of bubble screens.

The first is an application in which, when the user presses a button, an omnidirectional screen capable of touch input is rapidly formed in front of the projector lens, allowing the user to operate the menu at hand. At this time, the user can return to normal projection by simply destroying the screen when the operation is finished.

Second, the proposed system is capable of expressing the entire process of shape change by gradually feeding air into the soap film, from flat to hemispherical to spherical, and finally breaking (or flying). By projecting interactive images that reflect the user's touch and the explosion of soap bubbles on this process, we believe that it will be possible to express the beauty and fragility of soap bubbles.

Finally, we believe that the system can be used as a display to present the "presence" of the other party by projecting the other party's head onto a soap bubble at hand during a remote conference. In this case, the user would be able to inflate and sometimes explode the size of the display showing his or her own face in the other person's hand. This would allow the user to express emotions such as "excitement" and "joy" that are difficult to convey with the conventional "clap" button.

6. Outlook

As the next step, we intend to develop portable models based on prototypes to meet more application scenarios. Also, to explore better control methods for projecting on bubble surface and find better quality ingredients of the bubble. Besides, we also plan to develop new input methods other than break the bubble.

References

[1] Hrvoje Benko, Andrew D.Wilson, and Ravin Balakrishnan. Sphere: multi-touch interactions on a spherical display. In *Proceedings of the 21st annual ACM symposium on User interface software and technology*, pp. 77–86, 2008.

[2] Nikita Soni, et al. Adults' and children's mental models for gestural interactions with interactive spherical displays. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pp. 1–12, 2020.

[3] Yoichi Ochiai, et al. Poppable display: A display that enables popping, breaking, and tearing interactions with people. In *2013 IEEE 2nd Global Conference on Consumer Electronics (GCCE)*, pp. 124–128, 2013.

[4] Soichiro Toyohara, et al. Balloonygen: extended tabletop display embedded with balloon-like deformable spherical screen. In *Proceedings of the 24th ACM Symposium on Virtual Reality Software and Technology*, pp. 1–5, 2018.