Feeling Fireworks

D. Reusser[1,2], **E. Knoop**[1], **R. Siegwart**[2], **P. Beardsley**[1]
[1] Disney Research, Zurich, Switzerland
[2] ETH Zurich, Zurich, Switzerland
dorothea.reusser@gmail.com

ABSTRACT

We present Feeling Fireworks, a tactile firework show. Feeling Fireworks is aimed at making fireworks more inclusive for blind and visually impaired users, in a novel experience that can be shared by all. Tactile effects are created using directable water jets that spray onto the rear of a flexible screen, with different nozzles for different firework effects. Our approach is low-cost and scales well, and allows for dynamic tactile effects to be rendered with high spatial resolution. A user study demonstrated that the tactile effects are meaningful analogs to the visual fireworks that they represent, with sighted users able to label the correct correspondence of tactile-to-visual effects by a large margin over chance. Beyond the specific application, the technology represents a novel and cost-effective approach for making large scalable tactile displays, with the potential for wider use.

Author Keywords

Haptic I/O; Interaction styles

INTRODUCTION

Firework shows are enjoyed throughout the world as a primarily visual experience. To create an experience that is more inclusive to blind and visually impaired users, we have made a large-scale tactile display to generate tactile fireworks that are directly analogous to physical fireworks happening in the sky. Inclusive and assistive technology typically has a functional goal, but this work differs in having aesthetic intent. We envisage it as an installation at a firework show that attracts all crowd members to share the experience of *feeling fireworks*.

To effectively render a tactile firework show, we require a fast tactile display with high spatial resolution. Although large-scale tactile displays have been developed such as inFORM [2] and TableHop [7], the respective technologies cannot be readily scaled up to large-scale low-cost displays with high spatial resolution. Techniques such as the Tactile Brush [3] and ultrasound haptics [5] are not suited to the interaction modality of a screen. A method such as Tesla Touch [1] is unlikely to provide the tactile gamut and spatial resolution required for compelling firework effects.

UIST'17 Adjunct, October 22-25, 2017, Quebec, Canada
ACM XXX-X-XXXX-XXXX-X/XX/XX.
http://dx.doi.org/XX.XXXX/XXXXXXX.XXXXXXX

Figure 1. Feeling Fireworks is a large-scale tactile display which generates a tactile firework show, providing an extra dimension for blind and visually impaired users in the context of a universal experience that is shared by all.

Our novel approach to the problem is to create tactile effects by spraying water jets onto the back of a flexible screen while a user senses the impact on the front surface, as shown in Fig. 1. The water nozzles are mounted on pan-tilt units to render movement, and different nozzles create different effects. The effects are highly dynamic, and the moveable nozzles allow us to create fireworks that move smoothly across the screen. Feeling Fireworks also incorporates projected visual fireworks, and the screen is interactive.

TECHNOLOGY

A schematic of the system is shown in Fig. 2. The size of the device is $106 \times 96 \times 215$ cm. The screen is latex and has dimensions $\sim 1 \times 1$ m. Water is moved through the system in a closed cycle by a controllable pump that provides variable water pressure. An Arduino controls the pump, the pan-tilt of the nozzles, and the opening and closing of the nozzle valves.

We use different nozzles for different firework effects. There are three jet nozzles for creating rockets and explosions, one shower nozzle for creating crackle effects, and one nozzle with a novel design for a blooming flower effect. Compound fireworks are created by sequencing effects.

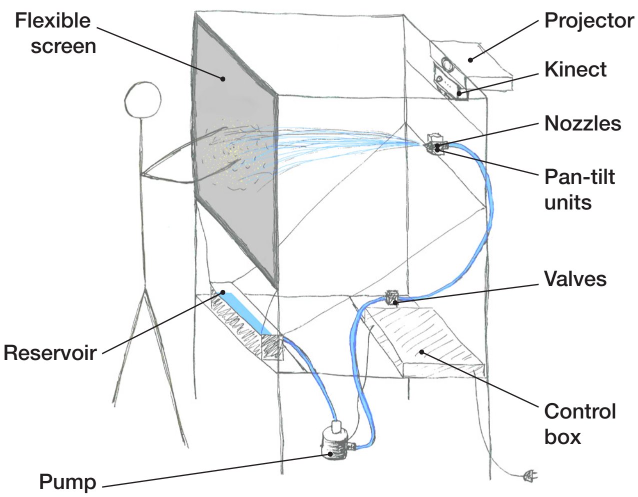

Figure 2. Schematic drawing of the Feeling Fireworks tactile display.

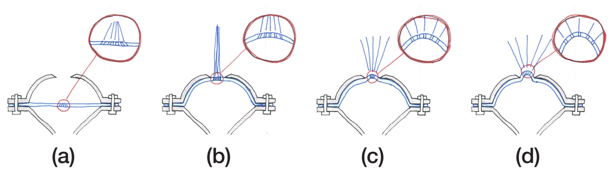

Figure 3. Custom nozzle developed for the flower effect. Increasing the water pressure causes the membrane (blue) to bulge outwards and the beams of water to diverge.

Rear projection provides visual content, and a rear-mounted Kinect detects a user's finger press on the flexible screen to provide interaction, similar to the eTable [4]. A laptop controls the projector and Kinect.

Flower Nozzle

A central effect in firework shows is the *flower* effect — an explosion in the sky that starts at a single point and forms an expanding circle of light points as shown in Fig. 1. We have developed a novel custom nozzle with a spray pattern that mimics the flower firework by starting off as a single column of water and creating an expanding cone as the pressure is increased. A schematic view is shown in Fig. 3. The nozzle has a silicone membrane with small holes through which the water flows. The membrane is flat when the nozzle is off (Fig. 3a), and is tuned so that the nozzle produces a single column of water at the lowest operating water pressure (Fig. 3b). Further increasing the pressure creates a continuously-expanding cone of water (Fig. 3c-d).

FOCUS GROUP AND USER STUDY

During the development process, we worked together with members of the blind community in a focus group to discuss the experience.

To evaluate the correspondence between the tactile firework effects and the physical fireworks that they represent, a user study was carried out with sighted users. 18 participants were asked to sample individual tactile fireworks and assign them to video clips. The study was based on ten tactile fireworks and a corresponding ten video clips.

		Played Tactile Effect									
		1	2	3	4	5	6	7	8	9	10
Chosen Visual Effect	1	30	0	2	0	0	0	0	0	0	0
	2	2	23	2	0	0	0	0	2	0	0
	3	0	0	27	1	0	0	0	0	0	0
	4	0	2	0	25	0	0	0	10	1	0
	5	1	0	4	0	14	1	8	0	3	2
	6	0	0	0	2	9	22	3	1	1	0
	7	1	1	0	0	12	13	24	0	1	10
	8	0	6	1	7	0	0	1	21	0	0
	9	2	0	0	0	1	0	0	0	29	2
	10	0	4	0	1	0	0	0	2	1	22

Figure 4. Confusion matrix of user study results. 66 % of tactile fireworks were correctly identified.

Fig. 4 shows the confusion matrix that summarizes the results from the user study. As indicated by the strong diagonal, overall performance was good with 66 % of fireworks being correctly identified. For comparison, pure chance association would be 10 %. We also observed that a small number of fireworks were ambiguous with each other and responsible for most of the incorrect responses. We can avoid these ambiguities when designing a firework show.

In summary, the result indicates good correspondence between the tactile fireworks and the visual fireworks they represent. For sighted users, the results suggest that sampling the tactile firework show while viewing the physical show in the sky is meaningfully multi-modal. For blind or visually impaired users, the tactile firework show is an analogous and shared experience with sighted users, in accordance with our goal of inclusivity.

PRACTICALITIES OF DEPLOYMENT

The device is free standing, on caster wheels for ease of movement, and runs off one standard power cord. It has been designed to be modular and transportable with easy setup. The pump is a near-silent medical product, while the water jets make a light drumming sound on the plastic screen which is audible but unobtrusive. The back-projected visual fireworks are clearly visible outdoors at night or in regular indoor lighting conditions. The device sits in a plastic tray to prevent accidental water leakage.

CONCLUSION

This work has presented a novel design of tactile screen that is scalable and economic, and which has been used to make a tactile firework show. It provides an extra dimension for blind people at a traditional firework show, in the context of an inclusive experience shared by all. A user study showed that the tactile fireworks are meaningful analogs of visual fireworks. Beyond this work, there are further possibilities — for example, the use of balloons by deaf people to feel music [6] suggests that a tactile-visual screen could be the basis of an inclusive musical experience for all.

ACKNOWLEDGMENTS

Our thanks to the Schweizerischer Blinden- und Sehbehindertenverband (SBV) for their invaluable input on the perspective of the blind and visually impaired community, and to Maurizio Nitti for the project banner.

REFERENCES

1. Bau, O., Poupyrev, I., Israr, A., and Harrison, C. Tesla Touch: Electrovibration for touch surfaces. *UIST'10 - Proceedings of the 23nd Annual ACM Symposium on User Interface Software and Technology* (2010), 283–292.
2. Follmer, F., Leithinger, D., Olwal, A., Hogge, A., and Ishii, H. inFORM: Dynamic physical affordances and constraints through shape and object actuation. *UIST'13 - Proceedings of the 26th Annual ACM Symposium on User Interface Software and Technology* (2013), 417–426.
3. Israr, A., and Poupyrev, I. Tactile Brush: Drawing on skin with a tactile grid display. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (2011).
4. Kingsley, P. eTable: A haptic elastic table for 3D multi-touch interactions. Master's thesis, University of Bristol, 2012.
5. Long, B., Seah, S., Carter, T., and Subramanian, S. Rendering volumetric haptic shapes in mid-air using ultrasound. *ACM Transactions on Graphics 33*, 6 (2014).
6. Nature News. Deaf people use 'mind's ear' to process vibrations. `http://www.nature.com/news/2001/011127/full/news011129-10.html`, 2001.
7. Sahoo, D. R., Hornbæk, K., and Subramanian, S. TableHop: An actuated fabric display using transparent electrodes. *CHI'16 - 34th Annual ACM Conference on Human Factors in Computing Systems* (2016), 3767–3780.