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Relief: A Scalable Actuated Shape Display

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ABSTRACT

Relief is an actuated tabletop display, which is able to render and animate three-dimensional shapes with a malleable surface. It allows users to experience and form digital models like geographical terrain in an intuitive manner. The tabletop surface is actuated by an array of 120 motorized pins, which are controlled with a low-cost, scalable platform built upon open-source hardware and software tools. Each pin can be addressed individually and senses user input like pulling and pushing.

Author Keywords

Pin array, Haptic display, Tangible Input, Shape Display, Relief Interface

ACM Classification Keywords

H.5.1: Multimedia Information Systems—Artificial, augmented and virtual realities; H.5.2 [Information Interface]: User Interface - Haptic I/O.

INTRODUCTION

Creating tangible interfaces that are not only coupled with digital information as mere static physical objects, but can also be actuated, is a common emerging topic in HCI research [5, 6]. An example of this domain is shape displays, which can change their physical appearance to provide a haptic 3 dimensional experience in addition to graphic output. While a number of approaches to create shape display have been proposed, most of them are complex to build and therefore often unavailable to the HCI community. “Relief” utilizes commercially available components and open source hard- and software to provide a comparably low-cost, scalable platform, which can be used for creating prototypes with a variety of form factors and applications domains. The display is both able to render shapes and sense user input through a malleable surface, which is actuated by an array of electric slide potentiometers.

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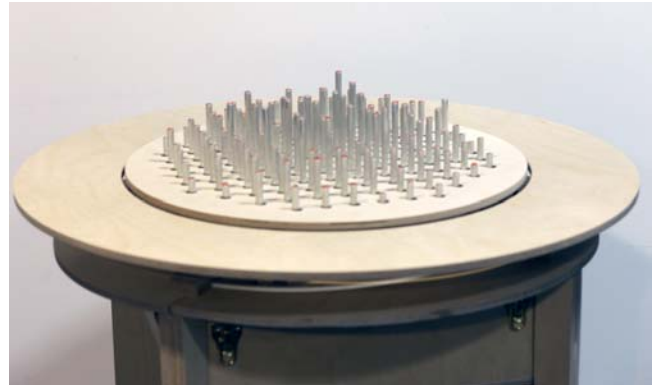


Figure 1. Relief system with uncovered aluminum pins.



Figure 2. Relief system with pins covered with Lycra surface and top projected landscape.

RELATED WORK

A well-known example of a shape display is FEELEX by Iwata et al. [3], where 36 motorized pins actuate the shape of a soft surface, onto which graphics are projected. Lumen by Poupyrev et al. [7] utilizes shape memory alloy to actuate pixels on a tabletop display. The Terrain Table by Northrop Grumman is a large high-resolution tabletop pin display utilized for geospatial military applications [8]. Most proposed systems use custom hardware with a high mechanical complexity, which often limits the scalability. Some research projects like Digital Clay by Haihong [4] address these issues for possible future commercial production. However, low-cost solutions are still unavailable to HCI researchers today.

Electric slide potentiometers have previously been utilized to create actuated arrays for sensing user input and rendering shapes, such as in AR-Jig by Anabuki and Ishii

[1]. Another example of a 2D array using electric slide potentiometers is Glowbits by Hirschmann [2]. Both these projects feature unique form factors for specific application domains. In contrast, the aim of the Relief project is to create a generic platform for a wide variety of applications and interactions, which can be extended with a minimal effort.

IMPLEMENTATION

Hardware

To minimize cost and complexity of the system, all parts were built from commercially available components. The current setup has an array of 120 aluminum pins built into a circular tabletop. The pins are spaced 1.5 inches apart from each other and can protrude 5 inches from the table surface. Every pin is actuated by an electric slide potentiometer¹, commonly utilized in audio mixing boards. The advantage of using electric slide potentiometers is fast actuation combined with very precise sensing in a relatively compact package. Each potentiometer is equipped with a DC motor, which is controlled by an Arduino² board with an attached Ladyada³ motor shield. As each of these boards can drive 4 motors, 32 boards are used in our current setup. Each of these elements together with 4 slide potentiometers is assembled into a wooden box, which forms an independent unit in the system. The advantage of this design approach is the possibility to change the physical configuration of the pin array easily and have fast access to faulty elements without complex disassembly. All units are connected in a serial chain to forward messages to and from the computer. The units receive unique addresses with a running counter message when the system starts up to enable addressing each pin individually.

Software

The current hardware interacts with applications built upon the open source development environment Processing. Our reasons for using Processing where it's ease of use, build-in serial library, portability and the fact that it is free of cost. Each Arduino board runs a program to sense the position of the connected pins and control the motor to reach the desired position. The pin position is sent to an application running on a connected computer, which keeps track of the correlation between all pin positions and the 3D model. The same program also outputs graphics, which are projected back onto the tabletop to augment the shape display.

Application: Geospatial Exploration

The first example application of our system features geospatial exploration. Figure 2 depicts the display rendering a 3D model of a landscape, while the landscape texture is projected onto a Lycra surface covering the pins.

¹ Alps RSA0N11M

² <http://www.arduino.cc>

³ <http://www.ladyada.net/make/mshield/>

CONCLUSION

Relief is the first version of an actuated shape display based on our scalable hardware platform. The prototype was demonstrated for multiple days at Ars Electronica 2009 and initial user reactions were very promising, however we have not conducted a formal user study at the time of writing. As the individual actuation modules of the platform were designed to function independently from each other, we plan to build future versions with different sizes and form factors. Such versions could include expressive digital sculpting tools and music controllers, as well as multiple connected versions for remote collaboration.

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REFERENCES

1. Anabuki, M. and Ishii, H. 2007. AR-Jig: A Handheld Tangible User Interface for Modification of 3D Digital Form via 2D Physical Curve. In *Proceedings of the 2007 6th IEEE and ACM international Symposium on Mixed and Augmented Reality* (November 13 - 16, 2007). Symposium on Mixed and Augmented Reality. IEEE Computer Society, Washington, DC, 1-10.
2. Hirschmann, D. Glowbits. Demo at Ubicomp 2004. <http://www.glowbits.com/>
3. Iwata, H., Yano, H., Nakaizumi, F., and Kawamura, R. 2001. Project FEELEX: adding haptic surface to graphics. In *Proceedings of the 28th Annual Conference on Computer Graphics and interactive Techniques SIGGRAPH '01*. ACM, New York, NY, 469-476.
4. Haihong, Z. 2005. Practical Structural Design and Control for Digital Clay. Dissertation, Georgia Institute of Technology, Atlanta.
5. Parkes, A., Poupyrev, I., and Ishii, H. 2008. Designing kinetic interactions for organic user interfaces. *Commun. ACM* 51, 6 (Jun. 2008), 58-65.
6. Poupyrev, I., Nashida, T., Okabe, M. Actuation and Tangible User Interfaces: the Vaucanson Duck, Robots, and Shape Displays. *Proceedings of TEI'07*. 2007: ACM: pp. 205-212.
7. Poupyrev, I., Nashida, T., Maruyama, S., Rekimoto, J., and Yamaji, Y. 2004. Lumen: interactive visual and shape display for calm computing. In *ACM SIGGRAPH 2004 Emerging Technologies* (Los Angeles, California, August 08 - 12, 2004). H. Elliott-Famularo, Ed. SIGGRAPH '04. ACM, New York, NY, 17.
8. Northrop Grumman Terrain Table: <http://www.is.northropgrumman.com/products/terraintable/index.html>