Towards Real Organic User Interfaces - Using Non-Newtonian Fluids for Self-Actuated Displays

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Figure 1: Interacting with a "Cornstarch Monster".

CHI'13 Workshops, April 27May 2, 2013, Paris, France.

Abstract
In this paper an approach for a large scale self-actuated tabletop surface based on non-Newtonian fluids is presented. Besides the change of the viscosity of the surface I discuss how different forms of actuation can be achieved.

Author Keywords
Organic User Interfaces, Shape Displays, Non-Newtonian Fluids, Haptic, Touch Surfaces,

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

General Terms
User Interfaces, Interaction Techniques

Introduction
In the last five to eight years an increasing amount of research focussed on interactive tabletops and touch surfaces. Most of these prototypical surfaces where rigid and non deformable. Even though a variety of materials and technologies exist that would allow to actuate and

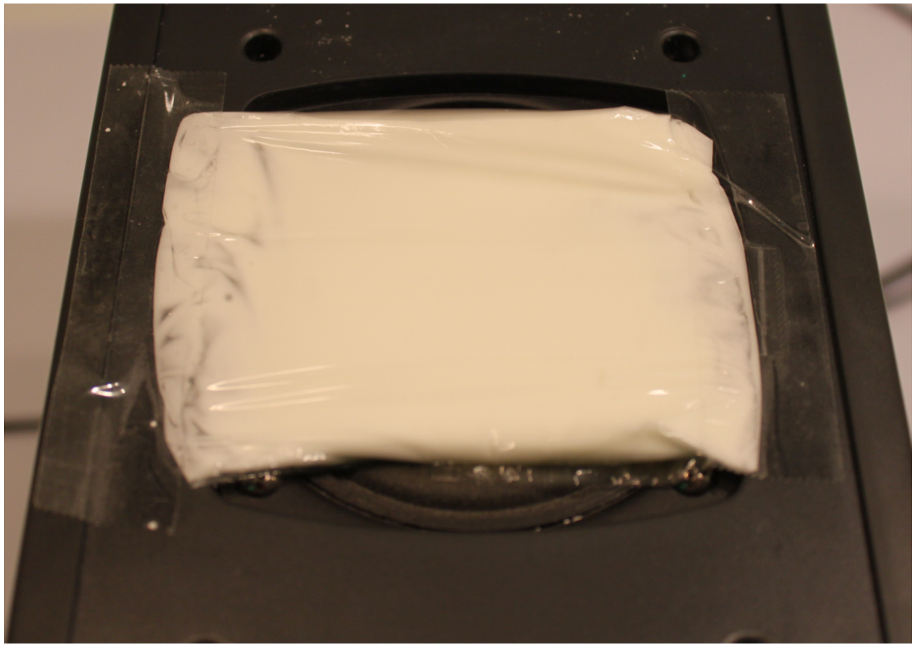

Figure 2: Two transparent coated layers filled with Oobleck. Through the activation of the speaker below the surface can be changed from organic, liquid malleable to a solid surface that can be enhanced with vibro-tactile feedback.

enhance those surfaces, the cost of creating a surface like [2] or the presented prototypes of [9] in size of a large tabletop would be very high. Furthermore haptic feedback on such tabletops is insufficiently investigated since it is hard to realise at a large scale as well. In this paper I propose an approach for a large scale self-actuated tabletop surface based on non-Newtonian fluids. This approach allows to create a self-actuated top-projection surface at a very low price point. Based on cornstarch and an array of speakers a surface can be created that can change in texture, allows to create pop-out buttons as well 2.5D sculptures.

Non-Newtonian Fluids

The term *viscosity* is used to describe and measure the resistance of a fluid to being deformed or flow. This can either be caused by shear stress or tensile stress. While for Newtonian fluids (named after Isaac Newton) such as water or honey the viscosity is only influenced by the temperature, the viscosity of non-Newtonian fluids also depends on the force applied to the liquid. At room temperature water, a Newtonian fluid, has a very low viscosity while honey, being also a Newtonian fluid, has a very high viscosity. If the honey is heated the viscosity decreases and it becomes more "fluid". An extreme example of Newtonian fluids would be lava. In contrast to that the viscosity of cornstarch, a non-Newtonian fluid, is independent from the temperature only influenced from the force that is applied to it. While no force is applied, Oobleck, a mixture of water and cornstarch is liquid and has a low viscosity, but if a force is applied such as a sudden press on the surface the viscosity increases and the liquid becomes nearly a solid. Since the force applied to the fluid is transmitted through the medium the surroundings of a possible touch point increase in viscosity as well. This leads to the famous phenomena of the so called "Cornstarch Monsters" where the percussive action of a speaker causing Oobleck to increase its viscosity and expand in 2.5D, as can be seen in Figure 1.

Concept

Oobleck - the mixture of cornstarch and water - has originally a white colour that can serve as a top projection surface as can be seen in Figure 1. If needed it can also be given a different colour using food colouring. Filled in a layer between two coated films as done in [4] it can serve as a malleable surface that has an organic feel to it but can be turned into a solid rigid surface. An array of small speaker ordered in a grid placed below the Oobleck

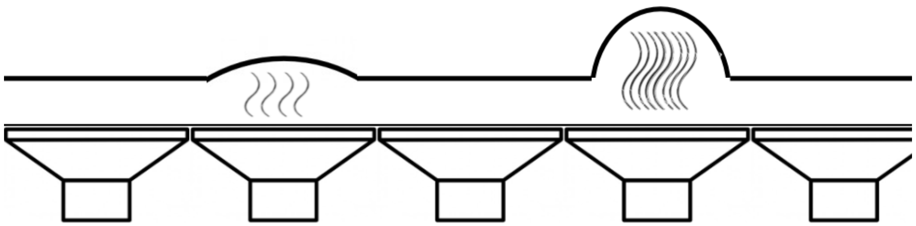

Figure 3: An array of speakers is used to actuated a Oobleck layer that allows to create inflatable buttons.

would allow to activate it through the percussive force and change its viscosity on demand in different parts of the surface demand (compare Figure 2). The usage of speakers has several advantages, besides being cheap compared to for example SMA's they are also easy and accurate to operate compared to for example magnetic based systems [5]. Furthermore Oobleck can be actuated instantanious to be either liquid or solid and does not require a heating phase such as SMA's. By interpolating the frequencies and amplitude across the speakers the whole surface can be actuated. To detect touches several sensing techniques are imaginable. Besides flexible capacitive touch-screen layers also the Microsoft Kinect could be used. In the following I will discuss possibilities to further actuate such a surface besides changing the viscosity of the surface.

Tactile Feedback
Changing the viscosity of the surface automatically changes the tactile feedback of the area that is activated since the surfaces becomes solid instead of malleable. A similar behaviour also has been produced by the Mudpad [5] using magnets and ferromagnetic fluids. Rasmussen et al. also refer to it as "the illusion of shape change" [8]. With the surface being in the solid state the speakers also can be used to create vibro-tactile feedback by increasing the amplitude. In such a way the whole surface can have vibro-tactile nuances. Besides this also thermal feedback could be integrated since the liquid could easily be heated.

Inflatable Buttons
Using small pockets in the coated top film as in [1, 3] would allow to create something that Harrison and Hudson call "just-in-time affordances" [3]. Inflatable buttons that are popping out due to the Oobleck increasing in size as it would when building "Cornstarch Monsters" (compare Figure 3). With changing the amplitudethe pockets in surface could be filled to different levels and size and with this it would allow for different heights of the buttons. This behaviour is very comparable to [3] or [10] where pressured air was used to create the same effect. Of course not only buttons can be created but rather many different shapes, also sliders which positions could be indicated by interpolating between different speakers.

2.5D Sculptures
The "Cornstarch Monsters" are unfortunately very indeterministic and will not reproduce the same sculpture based on frequency and amplitude of the corresponding speaker. But the basic shape that they generate could be modified by force applied from the top and the sides. Similar to [7] ultra sonic speakers could be utilised to create a force and stabilise the "Cornstarch Monster"-Sculptures and manipulate them. Another possibility would be to use for example compressed air to create this force. Besides the increased amount of hardware this would require also sophisticated tracking techniques to detect and control the 2.5D sculptures would be needed. But the basic "Cornstarch Monsters" could also be used for notification or other adorable more

lifelike animations with additional projection [6].

Conclusion

In this position paper I discussed several different ideas how non-Newtonian fluids can be utilised for self-actuated deformable projection surfaces. Besides being cheap and compared to magnetic approaches easily controllable further technical investigation is needed to exploit the full capabilities of such surfaces. Overall non-Newtonian fluids are an interesting alternative for such deformable displays and I would argue to further investigate their capabilities in such use cases.

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