# MagneTexture: A Non-Visual Tangible User Interface

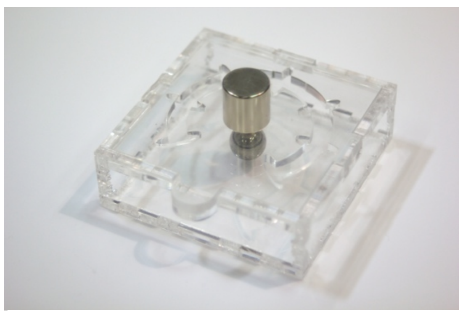

Fig 1 Transparent MagneTexture showing the details of the texture plate, in this case a notched rotary dial.

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## Abstract

The aim of this research is to explore how rich textural and haptic information can be presented in a tangible user interface with the minimum of accompanying visual representation. Our approach came from the observation that Tangible User Interfaces (TUIs) tend to prioritise visual information over tactile information, with the rich possibilities and subtleties of haptic interaction often being eschewed in favour of intangible visual displays. In response to this observation, we designed a series of *MagneTexture* design probes to explore how a TUI can be made to be entirely non-visual. Our approach aims to contribute to the 'Touch Me' workshop through introducing the Feelable User Interface (FUI) concept and showing how MagneTexture allows the non-visual presentation of tactile information for the purposes of self-reporting emotional experience.

## Keywords

Haptic; Tactile Exploration; Touch; Non-Visual; Texture; Tangible User Interface.

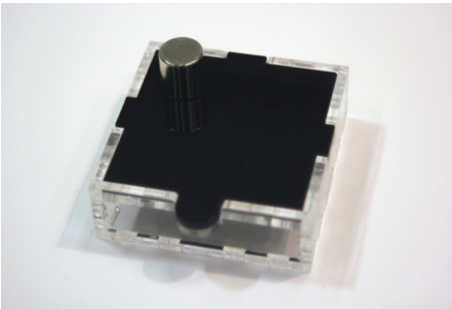

Fig 2 Opaque MagneTexture box. The user uses the magnetic puck on top to move the ball around inside the box.

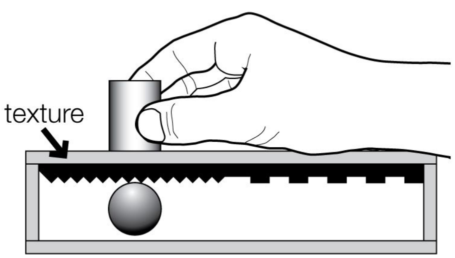


Fig 3 Cutaway view of ball, magnet and texture plate.

## ACM Classification Keywords

H5.2 [Information interfaces and presentation]: User Interfaces. - Input Devices and Strategies.

## Non-Visual Tangible User Interfaces

Tangible User Interface research aims to bring the realm of digital bits into the world of atoms, embodying virtual information in real world physical objects. Despite this focus on physical interaction with objects, we have observed that many tangible user interfaces, although based around interesting tangible interaction tend to rely heavily on visual information, commonly in the form of digital projections around the physical objects. This is something that we regularly experience first-hand in our own design practice, when we aim to create a strongly haptic interaction but frequently end up adding additional functionality through visual means.

Our response is to propose the concept of 'Feelable User Interfaces' 0, a distinct subset of Tangible User Interfaces that deliberately minimise the amount of visual information presented to the user. The aim of a Feelable User Interface is that the reduction or removal of visual information will place greater emphasis on the haptic experience, and remove the influence of the visual stimulus on the user's perception of the haptic material. MagneTexture is our first example of a Feelable User Interface and investigates how a magnet can be used to manipulate hidden objects (Fig 1). The manipulation of the object, a steel ball bearing, transfers forces through the magnet back to the user, creating a haptic experience with no accompanying visual feedback on the ball's state.

## MagneTexture Design

The key difference between a haptic force-feedback device and a TUI is that in a haptic display, the display simulates interaction with a virtual object by applying forces to the user, whereas in a TUI the user interacts with a real object. Hence, simply turning off the display screen can easily make a haptic device (such as a Phantom) entirely non-visual. In contrast, 'turning off the visuals' is not as easily accomplished in a TUI as the physical element of a TUI remains visible even if any accompanying projections are removed. Hence, the first step of designing a Feelable User Interface is to obscure the tangible objects that are being manipulated. A number of methods for this would be possible ranging from blindfolding the user, through to placing the object out of sight. In MagneTexture we opt for placing the tangible object within an opaque box (Fig 2).

Given that the object we wish to control is contained within an opaque box, the next design question is how can it be manipulated? One approach is to tilt and move the container in order to move the object inside, however this is quite a disconnected experience, as the object can only be felt through weight changes and collisions with the container. The approach we chose is to use a metal ball bearing inside the box and use a magnet to move the ball around, thus creating a strong link between the user and the ball, without visually revealing the details of the texture plate (Fig 3). Currently we are still exploring how the user perceives this system and whether the locus of the interaction is perceived to lie in the magnet, the ball or the texture.

The MagneTexture hardware consists of an acrylic opaque box (12cm x 12cm x 3 cm) with a removable

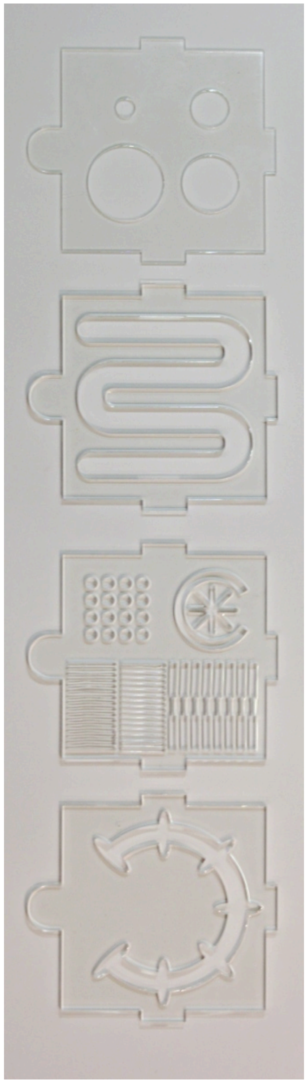

Fig 4 Texture plates.

lid. A ball bearing (2cm diameter) is placed within the box, and an interchangeable texture plate is placed directly underneath the lid (Fig 4). The user places a magnet on the lid of the box to manipulate the ball bearing inside (Fig 3). The position of the ball is tracked with the use of a grid of hall effect sensors. Servomotors can be used to actuate the texture plates, thus allowing computer controlled texture modification.

## Haptic Exploration

MagneTexture aims to promote the importance of haptic exploration in the operation of a TUI. In human-computer interfaces, haptic exploration, such as texture simulation is mainly designed through exploring the perception range of digitally provided haptic stimuli. In *TeslaTouch* [2] or *REVEL* [1] electric stimuli provides tactile information for stimulating different surface patterns or texture roughness by varying in intensity and frequency. Our goal is to investigate the perception of analogue textures for getting insight in user experience that can serve for digital texture design. In that manner our approach is different from *TeslaTouch* and *REVEL* as we explore the possibility of human's haptic perception rather than the perceivable expressiveness of haptic output interfaces. In previous work on analogue haptic perception, prefabricated textures such as sandpaper [9], [5] were used, or researchers employed textures that were made from engraved aluminum [6] or photoengraving [7], [3], [1], [4].

## Texture Gradients and Emotional Response

The relationship between the textures displayed in MagneTexture and emotional self-reporting have yet to be established. Below we highlight some possible texture types that could be used as a starting point for further investigation. One MagneTexture box can contain a number of different textures in order for the user to report a number of different states. Importantly 'texture gradients' can be created between two opposing types of texture allowing the possibility of reporting the magniture of the emotional response. The x,y position of the ball can be tracked over time allowing the gathering of information such as dwell time on particular textures, or speed of movement through different textures. Examples of the types of texture gradients that can be created in a MagneTexture plate are listed below:

*Intricate - Simple*
*Dynamic – Static*
*Soft – Sharp*
*Strong Force – Weak Force*
*High Friction – Low Friction*

Currently we can only hypothesise how these texture gradients relate to emotional states, with further testing necessary for validation. An example of a possible mapping would be sharp textures relating to pain/fear and soft smooth textures relating to happiness/comfort. Another may be unordered and complicated textures mapping to confusion/surprise.

The haptic exploration of the probes may promote fiddling/twiddling as an input method as the user absent-mindedly explores the probes texture plate whilst watching the stimulus material. The non-visuality of the probes may encourage this behavior as there is no need to visually observe the device while interacting. This non-visual interaction may also be important for privacy as bystanders or other participants will not be able to see the choice made by

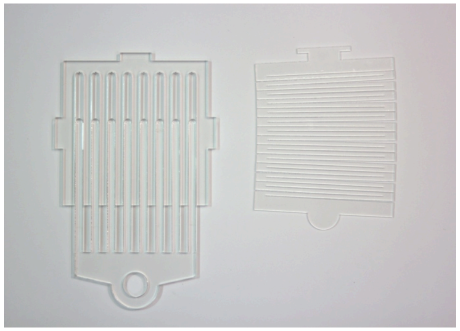

Fig 5 Modifiable texture plates.

the user. There are three proposed benefits of using MagneTexture as a tool for self-reporting emotional experience:

*Low Cost*
MagneTexture devices can be made cheaply. The texture plates are laser cut acrylic and can be quickly made with a custom design. No Motors are necessary in the passive probes, however low cost servomotors can be used to actuate the texture plates if necessary.

*Measurement of Interaction*
For tracking the users' movements of the ball, either a webcam or hall-effect sensors can be used. Using a grid of hall-effect sensors placed on the bottom surface of a MagneTexture device allows the ball's position to be tracked without adding extra bulk, allowing the device to remain handheld.

*Systematically Varying Textures*
As the fabricated prototypes are based on digital files they can easily be changed, allowing for a systematic exploration of different textures and paths, whilst also enabling highly controlled experimental set-ups.

## Conclusion and Future Work

We have presented MagneTexture as a method of presenting textural haptic information to the user and proposed that interaction with MagneTexture may aid in the self-reporting of the user's emotional state. In future work, we aim to make correlations between texture gradients and emotional states. Currently we have only explored the use of texture plates that are static, however the aim is to allow the computer control of textures through the use of servomotors physically actuating the texture plates (Fig 5) in real time.

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