Kinetic Tiles: Modular Construction Units for Interactive Kinetic Surfaces

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ABSTRACT

We propose and demonstrate Kinetic Tiles, modular construction units for *Interactive Kinetic Surfaces* (IKSs). We aimed to design Kinetic Tiles to be accessible and available so that users can construct IKSs easily and rapidly. The components of Kinetic Tiles are inexpensive and easily available. In addition, the use of magnetic force enables the separation of the surface material and actuators so that users only interact with the tile modules as if constructing a tile mosaic. Kinetic Tiles can be utilized as a new design and architectural material that allows the surfaces of everyday objects and spaces to convey ambient and pleasurable kinetic expressions.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces. - Prototyping.

General terms: Design

Keywords: Interactive Kinetic Surface, Kinetic Organic Interfaces, Kinetic Design Material

INTRODUCTION

Interactive Kinetic Surface (IKS) is a surface that embodies kinetic interactions [3]. By employing kinetic motion, IKS enables expressive surface which engages not only visual but also tactile and kinesthetic sensations. In addition, physical motion often enables physical transformability [6], which allows IKS to be actively adaptive. Since the development of these advantages, IKSs have been employed in several interactive art installations (e.g., [5]), adaptive architectures [1], and transformable interfaces (e.g., [2]). However, to build an IKS, considerable effort and professional techniques are required. Particularly, for product or environment designers, it is difficult to utilize IKSs due to technology barriers and, occasionally, cost concerns.

In this research, we focus on developing a type of *kinetic design material* to construct expressive IKSs. Notably, we aim to make the material accessible and available so that people can construct IKSs easily and rapidly with it. For this purpose, the material should have a proper form factor which can be easily manipulated. In addition, hiding technology within the design allows general users to use the material readily without complex instructions. Moreover, it should have a simple construction with off-the-shelf materials/actuator technology so as to be inexpensively manufactured. These requirements led us to the design and development of Kinetic Tiles, modular construction units for IKSs.

KINETIC TILES

Design Concept

As if constructing a tile mosaic, people can assemble Kinetic Tiles to create a kinetic pattern, text or icon. Individual tile modules can change their physical shape independently by separate actuators. The kinetic motions of each tile can be programmed either before or after the construction of an image.

Implementation

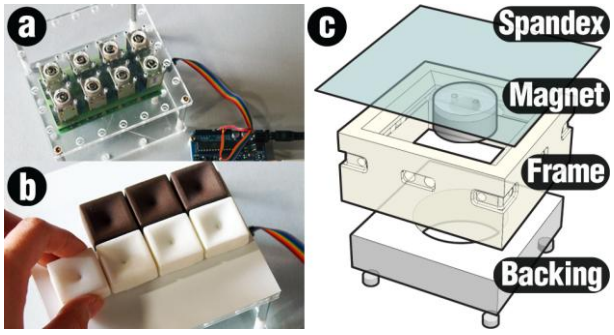

Figure 1: Construction of the Kinetic Tiles prototype: (a) an actuator array mounted under an acrylic frame, (b) tile modules placed on an actuation platform, (c) detailed structure of the tile module

The Kinetic Tiles prototype consists of an actuation platform shared by individual tile modules. The actuation part consists of a driver board and a matrix of electromagnets (see Figure 1a). Magnetic force enables the actuation platform to be separated from the tile modules (see Figure 1b). Therefore, Kinetic Tiles can conceal the actuators behind object surfaces so that the users only interact with the small tile modules.

The current tile module prototype is implemented in the same manner as our previous work, Shade Pixel [4]. As shown in Figure 1c, the tile module is topped with spandex fabric. Inside the module, a neodymium magnet is attached onto the back side of the fabric layer. Reacting to external electromagnetic force, the magnet deforms the surface of the tile. Each square tile has a width of 25 and a height of 11 mm. The deformation depth is approximately 7 mm.

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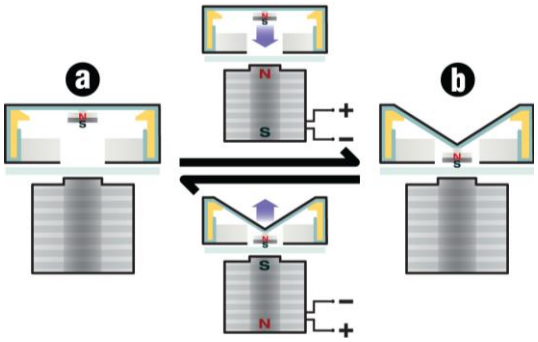

Figure 2: Bi-stable mechanism of Kinetic Tiles: (a) neutral state (b) negative state

Figure 2 illustrates the moving mechanism of Kinetic Tiles. Through the switching of the polarities of an electromagnet, the magnet attached behind the spandex moves up and down. Once the position of the magnet is set by the switching of the current, the magnet remains in a set position due to the restoring force of the spandex (see Figure 2a); otherwise, its magnetic force is attracted to the iron of the electromagnet (see Figure 2b). Therefore, no current is necessary to maintain the magnet position.

INTERACTION

After constructing a pattern or an image with Kinetic Tiles, the user can augment it by adding kinetic motions. Figure 3 offers a typographic example. Figure 3a represents the Chinese character "步", which means "walk", whereas Figure 3b represents "走", which means "run". We programmed the former to spread much slower than the latter. This lively means of expression allows the viewer to acquire the meaning of words intuitively.

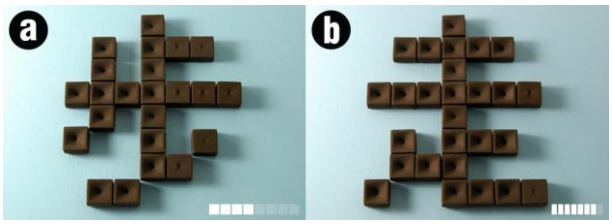

Figure 3: Speed as a variable: (a) walk (b) run

In Figure 4, the white tiles on the left side were animated to describe an octopus squirting ink. Combined with physical movements, the tiles create a dynamic sensation in which the flow of the liquid is depicted kinesthetically.

Figure 4: An octopus squirting ink

When the tiles are placed upon a pre-programmed surface, the user can reveal undertone pulsations created by the electromagnetic actuators. Figure 5 depicts a wave along a pre-programmed movement propagating from left to right.

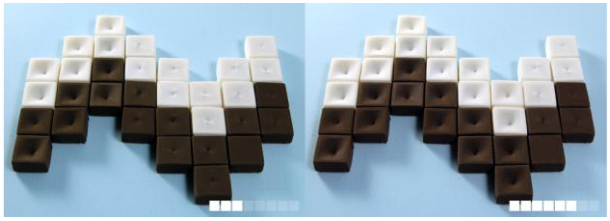

Figure 5: Wave propagating from left to right

CONCLUSIONS

In this paper, we have proposed and demonstrated Kinetic Tiles, modular construction units of IKSs. We aimed to design Kinetic Tiles to be accessible and available for general users. The components of Kinetic Tiles, such as the spandex and the electromagnets, are inexpensive and easily available. In addition, the use of magnetic force enables the separation of the surface material and actuators so that users only interact with the tile modules as if constructing a tile mosaic.

Future development will address extending Kinetic Tiles to support kinetic input. This will extend the possibilities of the design and creation of novel kinetic interfaces. Further exploration of surface materials and kinetic motions will allow different types of tile modules having diverse visual and kinetic attributes to be created.

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