ABSTRACT
This research focuses on the topic of interactive surfaces, especially those which embody kinetic interactions. Through the research, I will provide a definition and a theoretical framework for Interactive Kinetic Surfaces. Following a research through design approach, I will explore the design space of the Interactive Kinetic Surfaces and set the guidelines for applying them to our daily lives. In terms of research implementations, I plan to develop Kinetic Tiles and Kinetic Bricks, modular construction units of the Interactive Kinetic Surface. By adopting Interactive Kinetic Surface into the objects and environments, not only designers but also users will be able to facilitate responsive, pliant, and self-evolving surfaces, which can be described as a living interface. The following is a brief summary of the ongoing research.

Author Keywords
Interactive Kinetic Surface, Kinetic Organic Interface

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design

INTRODUCTION
A surface is the plane of contact or interface between people and things. Contemporary objects and spaces are cloaked in surfaces that masquerade as other materials, surfaces where the physical and the virtual, the real and the imagined, collide [4]. This research focuses on these new surfaces, especially those that embody kinetic interactions. I begin this paper by introducing Shade Pixel and Digital Rubbing, which led us to propose the concept of an Interactive Kinetic Surface.

SHADE PIXEL AND DIGITAL RUBBING
Shade Pixel [2] is inspired by sunken relief. Pixels with shade create dynamic patterns on a fabric surface. On the other hand, Digital Rubbing [1] is inspired by frottage and rubbing. Digital Rubbing allows copying a two-dimensional digital image instead of a physical texture. Both Shade Pixel and Digital Rubbing dynamically transform the physical or virtual topography of the surfaces which implement kinetic interaction. In the case of Shade Pixel, digital information is converted into the kinetic motion of the surface. On the other hand, in the Digital Rubbing, embedded information is converted into the movements of the external object, the TransPen.

INTERACTIVE KINETIC SURFACE
Inspired by Shade Pixel and Digital Rubbing, I propose a term Interactive Kinetic Surface. Interactive Kinetic Surface is a surface that embodies kinetic interactions. Interactive Kinetic Surface translates embedded information into physical (Physical Kinetic Surface) or virtual (Virtual Kinetic Surface) kinetic motion of the surface (see Figure 1).

Figure 1. (a) Physical Kinetic Surface (b) Virtual Kinetic
Physical Kinetic Surfaces translate embedded digital information into kinetic motion of the surface itself. The coupling between matter and information enables physical transformability, which embodies the malleability so valued in the digital realm [6]. Examples of Physical Kinetic Surface can be found in haptic surfaces and shape displays [7]. Furthermore, media art installations such as Rozin’s mechanical mirrors [5] take an aesthetic approach to Physical Kinetic Surface.

As opposed to Physical Kinetic Surfaces, Virtual Kinetic Surfaces are invisible and intangible. Therefore, they can only be perceived by means of an external mediator. Embedded information induces the kinetic motion of the mediator. The movement generates diverse feedback, including not only visual, but aural, tactile, and kinesthetic sensations, revealing the Virtual Kinetic Surface. This implicit and indirect interaction invites more active participation. Users should locate or move the mediator over the surface to interact with the Virtual Kinetic Surface. Pen-based haptic interaction [3] can be an example of Virtual Kinetic Surfaces. An actuated pen gives tactile feedback to GUI elements on a screen as if they physically
existed. Wearable devices for Augmented Reality, such as SenseableRays [8] also reveal virtual patterns or textures.

**DESIGNING INTERACTIVE KINETIC SURFACES FOR EVERYDAY OBJECTS AND ENVIRONMENTS**

Interactive Kinetic Surfaces embody many values not possible in traditional static surfaces of objects. However, it is difficult to find practical examples of an Interactive Kinetic Surface. As a result of designing Interactive Kinetic Surfaces that are more available and accessible in our everyday lives, I propose *Kinetic Tiles* and *Kinetic Bricks*, modular construction units of Interactive Kinetic Surfaces.

**Kinetic Tiles**

*Kinetic Tiles* are modular construction units of the Physical Kinetic Surface. Unlike other examples of Physical Kinetic Surfaces, Kinetic Tiles allows a simple and flat form factor by separating the surface material from the actuation part. Figure 2 illustrates the Kinetic Tile prototype. Kinetic Tiles consist of shared *actuation platform* and *tile modules*. First, the actuation platform consists of a matrix of electromagnets. Since electromagnetic force is used for actuation, the platform does not have to be connected directly to the Tile modules. Therefore, it can be *concealed* behind the wall or other surface of objects. On the other hand, the tile module can be designed to have various kinetic and visual attributes. For the actuation, tiles can be connected to the actuation platform directly, or can be put on the surface that embodied the actuation platform.

**Figure 2. Kinetic Tile prototype**

Kinetic Tiles can be used as a new artistic medium, which provides not only visual but also tactile and kinesthetic representation. The tiles can be used independently or assembled for decorating everyday objects or environments, making them *alive*.

**Kinetic Bricks**

Kinetic Bricks are building blocks of the Virtual Kinetic Surface. Kinetic Bricks consists of colored flat bricks. Bricks contain the information which can be translated into the kinetic motion of an *external actuated object*. One potential application of Kinetic Bricks is a construction toy for children. Children can create a virtual map by simply assembling Kinetic Bricks. Then they can explore the map with the various actuated mediators, such as a toy car. When the car passes over a certain Kinetic Brick, its wheel moves down and thus its body tilts as if it is moving on a raised bump.

Kinetic Tiles and Kinetic Bricks are still at an early stage and, as such, many challenges remain to be addressed. The next step will be the implementation of the concept of Kinetic Tiles and Kinetic Bricks. After that, user workshops will be conducted to evaluate the research implementations. Through the iterative design process, I will explore the design space of the Interactive Kinetic Surfaces and set the guidelines for applying them to our daily lives.

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