Chapter 6
Interaction Design with Kinetic Materials

Kinetic materials are intrinsically interactive, and thus, they are ideal materials for interaction experience. Through such materials, digital interactions can become richer, helping to create perceptually significant emotions, redefining sensorial and cognitive participation of users (Bengisu and Ferrara 2015).

Projects that use these materials as a key element to design user experience take on the role of shaping the flow of interaction over time. In fact, the big novelty brought by *kinetic materials* to a project is precisely the capacity to change form in time. Designers must learn to manage forms over time with the perceptual effects in a vision where interactive objects and spaces can be explored, inhabited, and enjoyed in time.

The term *interaction* indicates a mutual exchange between two or more persons, objects, materials, systems, or phenomena. The concept of interaction is based on the idea of a two-way action between the agents who maintain a relationship. Thus, interaction differs from the conventional cause and effect relationship.

In social sciences, interaction represents the sequence of dynamic, direct, or mediated relationships that determine social relations among individuals, groups, communities, through processes of verbal, written, graphic, or gestural communication.

Within the fields of design and architecture, interaction usually means a dialogue between the user and a given object, work, device, space, environment, or system. In the digital era, this concept has taken on a crucial importance because of the widespread use of personal computers, software, programmable machines, objects that are able to act and react, and devices that allow a complex interaction between man and machine. All such interactions are led by the human-computer interactions (HCI) discipline that emerged in the late 1970s. This field of study focused on the design of computer technology, and the interaction between humans and computers. With the exponential increase in the use of devices in everyday life, the discipline has expanded from electronic and computer engineering to cognitive sciences, to consider more and more human factors, encompassing interfaces as an element of the project.

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The user interface, usually referred to as graphical user interface (GUI), has attracted the interest of visual communication designers, for tasks ranging from the simple exchange of information to more complex interactions.

In the late 80s, scholars debated issues of interface design put in opposition to the IT approach. The IT approach emphasizes issues of usability, functionality, and ergonomics of computational and technical artifacts (now regulated by EN ISO 9241). This approach promotes visual design aspects in order to define the interaction and aesthetic dimension of the interface. In the same period Bill Moggridge and Bill Verplank coined the term *interaction design* to indicate the design of interactive digital instruments that facilitate the relationship between users and interactive products, services, and systems (Kjeldskov 2014). Today, interaction design is an important branch of design since interactive products are widespread.

According to Anceschi (1993), the *interface* is the scene where interactions between user and computer take place. Designing the interface involves shaping the "metaphorical osmotic membrane separating object and user", conceptualizing surfaces, atmospheres, adaptations between body and equipment, in order to open "perceptual doors" and "ergonomic bridges toward the action". This includes the design of communication codes with devices, made of textual, gestural, or oral languages. In our opinion this definition is a good way to introduce the concept of the *interactive user experience*.

6.1 Evolution of Interaction Design

Interaction design as a recent field has been enjoying continuous progress and growth due to developments in computer science and engineering, tactile input technologies, cognitive psychology, visual communication design, ergonomics, semiotics, etc. Many studies have been conducted to determine usability or to develop interaction design methods and processes. While usability is an important parameter, most experts in the field agree that the usability of an interface is not enough by itself to determine user satisfaction. Even if usability is deemed high according to specifications, an interface may not provide the expected sensory gratification or it may not completely perform the tasks expected from the application.

The digital age introduces new challenges for the society and the complexities it brings along necessitate that the relationship between the average user and interactive technologies should be enjoyable, complete, manageable, and easy to understand (Norman 2005). Many scholars have addressed the issue and expressed their views on a possible theory about interaction design, like Maeda (2006) whose approach is based on the principle of simplicity, or Norman (2005), whose approach is based on emotionality. Interdisciplinary researchers have investigated the *quality of interaction* by analyzing phenomena that occur when a user interacts with an interface. Such studies have been using experimental psychology methods and physiological measures like skin conductance, electroencephalography, and electromyography to understand the relationship between interface variables, user profile variables, and different aspects of interaction.

While experimental human-interface studies focus on physiological data, the *design approach* is a human-centered approach with an emphasis on sensorial perception, meaning, and emotions. This approach is based on the premise that the quality of interaction is highly concerned with its expressive output. The quality of the interactive experience depends on a number of fundamental choices that have a profound aesthetic nature. The experience of a specific user depends on the involvement of all human senses and the evolution of values and meaning of interactive use, employing a holistic view of social, material, and cultural phenomena (Battarbee 2007).

User experience (UX) design is an approach that concentrates its efforts on pleasurable and meaningful experiences. Experience design can involve any or all of the senses. A useful guideline in this field is to design the experience before the product (Hassenzahl et al. 2013). Experience design is becoming important in the field of interaction design for one more reason: the graphical user interface is transforming into a tangible one. Interface research based on the idea of *natural interaction* and *natural user interfaces* (NUIs) emphasizes how articulations of user requests can be similar to actions performed spontaneously in daily life, in order to achieve usability and perceived quality of interaction (Wigdor and Wixon 2011).

At this point, kinetic materials could play an important role for innovative solutions.

6.2 Exploring Interactivity in the Aesthetic Discourse

Moving to the fields of design and arts, the theoretical articulation on the interactivity of smart materials medium is still very poor. While experimentation on kinetic materials and their applications are emerging as a creative form, methodologies and critical parameters needed to develop a theory on design are still weak. One of the areas of inquiry that needs more development is the aesthetics of interaction, since critical investigation into the particular aesthetic experience enabled by these new media, which includes sensorial perception and validation of interactivity, has not been performed in detail.

Some studies on interactive experience were conducted in the field of arts. These studies concern the performativity of the interactive system in relation to the user's experience. According to Penny (2011), the performative aspects of interaction demand theoretical elaboration. In art practices that use digital technologies, negotiation is central between material and virtual, embodiment and technology, as well as performativity and content.

Exploring the aesthetics of interaction, Joseph et al. (2013) citing Määttänen (2005), state that all types of experience can be interpreted in terms of meaning, which are associated with different types of actions. In particular, they distinguish two types of actions: those based on the Aristotelian notions of *praxis* (doing, action) and *poiesis* (making, production). Based on this distinction, they suggest two types of experience: those that are valuable themselves and those that lead to other experiences. The significance of the artwork is mainly in the temporal and performative dimensions while capturing attention through personalization and participation in the performance.

As kinetic materials become more and more accessible and reliable, their applications in interaction design will grow, along with the necessity and opportunity of an aesthetic investigation. The design knowledge on these new tools require a thorough and theoretically supported conception that may be derived from research in the field of art as well as other branches. A critical analysis involving disciplines of design and aesthetics is needed (Russo and Ferrara 2017). That is why attention is being paid to the work of Shusterman in the field of design research. Shusterman is applying the principles of pragmatic aesthetics to interaction design, developing his own branch of research in relation to an emerging interdisciplinary approach, rooted in philosophical theory, that he called *somaesthetics*. This approach offers an “integrative conceptual framework and a menu of methodologies” to better understand somatic experiences through the gestures and other expressions of the human body, and to improve the perception, presentation, and interaction of our bodies (Shusterman 2011).

6.3 Smart User Experience

A new generation of products and services based on smart behavior is about to change the world around us. As soon as smart materials and systems, able to feel, react, interact and communicate, are applied in products, opportunities will appear for new functionalities that cut across and transcend traditional product boundaries.

This new generation of products, applications, and tools will deliver a new kind of experience to the user: a *smart user experience*. According to Worden et al. (2003) a smart user experience is a new class of experience based on smart materials, with the ability to sense changes in their circumstances and execute measures to enhance functionality under new circumstances. But, are we sure it’s all here?

Smart assistants, communicative objects, and devices that inform by leaving their traces or emitting beacons are not only changing many industries and business sectors, but also the way we will interact with an emerging world of smart devices, changing many product experiences and our lives drastically.

User experience is enhanced by smart materials and systems, as well as any other technology able to feel (listen), and adapt automatically in real time according to user behavior, context, any other specific condition that influence the design outcome and, eventually, the experience itself. A design-driven smart experience is accomplished when the interaction between man and his surroundings happens in an easy, natural, fluid, pleasant and gratifying way.

We are just at the beginning; most of the first commercial applications are still limited and partial but the list of services and products enhanced by smart technologies is growing every day. There are massive innovation opportunities for designers and industrial sectors. A smart experience combines smart materials with traditional ones. Consequently, the distinction between smart and common becomes less and less significant.

A well-designed user experience is the key for the success of any smart material. As more and more smart devices blend in around us, a satisfactory user experience becomes crucial for the adoption and efficacy of smart products. We need an integrated design approach that combines industrial design, interaction design, and service design to create smart experiences centered on users, their real needs, and desires.

6.4 Interaction and Emotions

Philosophers such as Baudrillard (2002) affirmed that, even by virtue of the materials used, objects can be transformed into symbols evoking, alluding, recalling, and amplifying the specific function for which they were designed. In the perceptual process, material is revealed as a complex entity that goes beyond the functional and technical dimension, to become value, status symbol, and meaning.

While satisfying ever more sophisticated needs, the design world discovered the importance of emotions. Emotions are part of the human experience while interacting with the natural world and artificial objects. Emotions influence the perception of the world and they may become affected by the characteristics of objects, and their interfaces, given that they mediate the relationship of people with the world. The form of an object, as well as its visible, tactile, and functional elements in the context of how they are used, stimulate emotions that are then interpreted in such a way as to trigger behavioral reaction mechanisms.

Design of emotions was born and diffused as a recent approach in order to stimulate emotions through aesthetic and psychological characteristics of the object (Norman 2005). Apart from tangible characteristics, it is the mode in which the interaction is sensed by the user, who evaluates it as positive or negative, enjoyable or stressful.

With the appearance of smart materials and intelligent objects, the concept of *emotional design* was integrated in the design process of computational systems as a tool to control and analyze the emotional aspects of projects (Zhang 2013).

6.5 Interactivity of Kinetic Materials and the Design of Tangible User Interfaces

Many devices interact with computers, including the mouse, keyboard, trackball, touchpad, light pen, and touchscreens. Until recently, interaction was accomplished through GUIs that display digital information on 2D screens. One of the big advantages of GUI is that redesigning a digital interface is much easier compared to an interface with real knobs and controls. In the former case, it is sufficient to change the icons related to a certain software or application in the case of a touchscreen. However, today researchers focus on the exploration of smart materials to correlate digital information with other senses, especially the sense of touch. Smart materials are used in combination with conventional ones in order to move the interaction from 2D interfaces to 3D. Thanks to the greater responsiveness of smart materials, objects can be designed to serve as tangible user interfaces (TUIs), capable of changing their appearance dynamically. The aim of this effort is to obtain 3D interfaces reconfigurable as the pixels of a screen to give a physical manifestation to data; to incorporate digital information into physical space.

Unlike GUI, TUI takes into account the way we perceive intuitively through our senses. Thus, TUI can provide a richer alternative to the graphical interface on the path of the ubiquitous computing vision set by Mark Weiser (Ishii et al. 2012).

Thanks to an increasing variety of possibilities brought by physical computational technologies, tactile and other sensorial qualities can be explored to build an intimate user-product relationship. Understanding relevant properties of materials and how they influence user engagement can provide meaningful insights to interaction design, especially to explore new applications of computational materials. Smart materials offer new possibilities to engage users because they can stimulate the senses and aid an intuitive understanding of the interaction, helping to make it a more enjoyable one. It is essential to understand how these new materials can transform user experience.

According to Hiroshi Ishii, director of the Tangible Media Group of MIT, it is necessary to think “beyond the screen” and find more efficient and direct ways to let people interact with technology. Information presented on a screen has been depicted as something at the bottom of the sea: you can see it, but not touch it. Therefore, Ishii and his team are trying to bring this information “on and over the surface of the water”, making them tangible (Ishii et al. 2012). Digital screens and artifacts can incorporate smart materials in order to transform our daily activities and make them richer, more enjoyable, and more gratifying.

6.6 New Forms of Interaction

Recently some researchers in the field of computer sciences and interaction design who try to recompose the computational and operational are designing two dimensions of materials in unison: the physical and the digital. These researchers try to encode information into materiality and give life to objects whose digital operation becomes tangible and capable to generate a rich, easily understood, aesthetic, and satisfying interaction experience. This approach intends to reveal the materiality of the object, bringing the analog and the digital worlds closer (Dunne 2005). These efforts could improve the capabilities of objects, bringing back the appreciation of material richness, which was lost during the leap from atoms to pixels (Coelho et al. 2007).

Interfaces can grow richer with smart and tangible media by improving the interaction and by overcoming some of the limitations that digital interfaces have. Implementation of smart materials in products and systems can improve the ease of operation (Ferrara and Bengisu 2014) and encourage pleasurable interactions by direct experiences via human senses. It can counter some of the problems caused by over-use of digital interfaces (Rosen et al. 2012).

Clearly, kinetic materials present a potential for new forms of interaction where the physical is merged and blended with the digital. Pending research questions include how tangible computing interfaces could transform the relationship between users and digital artifacts from social, ecological, technological, or emotional perspectives, how they could achieve certain design qualities compared to interaction with digital artifacts, and which strategies are suitable for designers that will work with physically enhanced computational technologies to promote sustainable interaction and pleasurable experiences.

Through the use of smart material interfaces, the appearance, texture, color, shape, size and other features of objects we use in our daily lives and buildings in which we live will be transformed from *passive* and *immutable* into *active* and *dynamic*. With the help of more research and product development activities, such changes will occur with the same ease and speed as digital forms change on our computer screens.

In the domain of architecture, building surfaces will not have to be rigid and immobile anymore. The form and appearance of buildings will gracefully change based on the demand of users or in response to environmental changes, in automatic or intuitive ways. Cities, buildings, and interiors will gain sensitivity, becoming *flexible* and *adaptable* to respond to changes throughout their lifetime.

Objects will be able to change shape based on the needs of a specific customer or application, incorporating the digital logic and open source programs, thanks to platforms like Arduino and Raspberry Pi. Interactions with products will gain features that are more expressive and serve new functions by incorporating a combination of digital and material entities.

A new generation of designers is appearing that combines the skills of product design, interaction design, and computer sciences. This hybrid skill is developed according to a human-centered design vision involved in the creation of products and experiences that aim to supply physical and psychological well-being. Improvement of quality of life and implementation of joyful experiences are targeted by this vision (Russo and Ferrara 2017). This must be the fulcrum of contemporary design. The future of design that awaits us will require evaluation of design in terms of perceptions, awareness, involvement, language, pleasure, emotions, relationships, as well as usability. Thus, the role of designers will be increasingly central, versatile, and at least as intelligent as emergent paradigms. We believe that interdisciplinary studies will continue to analyze how kinetic materials can be implemented in new frontiers of design to provide intelligent solutions.

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