

SOCIOTECHNICAL ENVIRONMENTS

PROCEEDINGS OF THE 6TH STS ITALIA CONFERENCE 2016

EDITED BY
STEFANO CRABU
PAOLO GIARDULLO
FRANCESCO MIELE
MAURO TURRINI

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Tangible Interaction and Cultural Heritage. An Analysis of the Agency of Smart Objects and Gesture-based Systems.

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Drawing on a design perspective, this paper aims to analyse the agency of tangible and embodied interaction systems applied to cultural heritage and the role of design in shaping the expected behaviour of users.

Going beyond tangibility in the strict sense of touching assets, in this paper we employ a broader interpretation of tangibility, understanding it as a practice of meaning-making that requires intense bodily involvement.

In order to carry out the analysis, we adopt the concepts of delegated and conditional agency proposed by Kaptelinin and Nardi (2009), the idea that things have the ability to realize –or not– the intentions that are delegated to them by someone else (the designer).

Therefore, different types of tangible interaction systems, (1) smart replicas/originals, (2) symbolic objects (3) codified gestures and (4) performing gestures, are analysed according to their ability to realize the intentions of those who imagined, created and programmed them.

Specifically, each category is described and analysed in terms of its ability to stimulate user interaction and suggest the right behaviour to trigger interpretive content. Finally, some conclusions are presented as a starting point to orient future research.

Keywords: *agency of things, tangible interaction, interaction design, museums, cultural heritage.*

Introduction

Tangible interaction emerged over the years as a way of integrating digital functionalities in the real world (Ishii and Ullmer, 1997). Originally

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born as a field of research within Interaction Design and HCI, today tangible interaction comprises a very broad range of 'systems and interfaces relying on embodied interaction, tangible manipulation and physical representation (of data), embeddedness in real space and digitally augmented physical spaces' (Hornecker and Buur, 2006, p. 437). Tangible interaction allows people to interact with digital systems as they usually do with the physical world, namely by manipulating objects or performing gestures or bodily movements.

Together with an increased interest in the materiality of the visit experience in museums and cultural institutions more generally (Chatterjee, 2008; Dudley, 2012; Pye, 2008), tangible interaction is progressively entering the cultural heritage field through systems such as tangible tabletops (Hsieh et al., 2010) smart objects (Rawat, 2005) and smart physical places (Ciolfi and Bannon, 2005). Although these systems have different shape and aims, they all offer interactions based on the manipulation of tangible, sensorised objects (object-based interaction) or free bodily gestures and movements (gesture-based interaction).

Significant research has been conducted in the field of tangible interaction applied to cultural heritage since the early 2000s. Notable projects include SHAPE (Bannon et al., 2005), which pioneered the introduction of tangible systems in the field, and the ongoing project meSch (Material EncounterS with digital Cultural Heritage), which aims to bridge the gap between heritage and digital content (Petrelli et al., 2013a) by creating prototypes and a platform allowing cultural heritage professionals to design, construct and maintain interactive artefacts. Furthermore, several applications and systems are also emerging from the commercial field and museum practice, giving rise to a rich panorama of projects.

It should be stated that, to date, the approach has mainly been practical and focused on the design and evaluation of new systems; not many theoretical works have been developed.

The authors have sought to classify tangible interaction applications in museums in a recent article (Duranti, Spallazzo and Trocchianesi, 2016), proposing four categories to identify embedded and embodied interactions in cultural institutions: (1) smart replicas/originals, (2) symbolic objects, (3) codified gestures and (4) performing gestures, the first two primarily related to embedded interaction and the last to embodied interaction.

The category (1) smart replicas/originals refers to examples that ask visitors to touch and manipulate replicas of artworks with embedded sensors or original artworks enhanced with sensing capabilities in order to

experience the sensorial aspects of the object and activate and control digital content.

Category (2), *symbolic objects*, instead, comprises projects that employ smart objects, icons or elements imbued with symbolic meaning. In other words, beyond its capacity to activate content in response to manipulation, the smart object becomes symbolic in itself by virtue of its shape and evocative power.

Category (3), *codified gestures*, covers examples that employ gesture-based interaction to control and activate interpretive content about the objects on display, namely projects that ask visitors to perform specific gestures in order to access digital content.

Finally, the fourth category (4), *performing gestures*, includes projects that ask visitors to perform gestures which, beyond their ability to trigger digital content, are imbued with meaning in relation to the asset on display.

The four categories of tangible/embodied interaction systems were originally proposed to consider the ability of these kinds of interfaces to stimulate reflections about the intangible value of cultural assets (Duranti, Spallazzo and Trocchianesi, 2016). The main focus was to define design strategies that would add meaning, namely embedding and embodying meaning in the sensorised object and visitors' gestures.

This article examines the aforementioned categories from another point of view, specifically analysing them in terms of their ability to stimulate user interaction, suggesting what visitors should do in order to trigger content. In other words, we study the agency of tangible and embodied interaction systems and the relations they establish with visitors.

A literature review about the agency of things

The concept of *agency* refers to the ability of an agent to act, in the sense of producing effects in the world. Traditional sociological accounts view the concept of agency as applying only to human beings (Kaptelinin and Nardi, 2009, p. 236), arguing for 'an asymmetric distribution of agency – all to human beings, none to the material world' (Pickering, 1993 in Kaptelinin and Nardi, 2009, p. 238). In a world in which 'modern technology behaves independently and flexibly in ways that traditional tools do not' (*ivi*, p. 237), however, the vision in which it is 'only people who are doing the acting' (Sheffer and Clinton, 2006, in Kaptelinin and Nardi, p. 237) becomes untenable (Pickering, 1993). Various theories have therefore emerged that challenge this traditional view, albeit in different ways. Actor-network

theory, for example, following the principle of *generalized symmetry* (Latour, 1992) ‘insists there is no difference between human and non-human agents: human and nonhuman agency can be continuously transformed into one another’ (Pickering, 2003 in Kaptelinin and Nardi, 2009 p. 238). According to other theories, the “perfect symmetry” postulated by actor-network theory is limiting because it fails to consider the different ways human beings and things have of acting, namely the fact that ‘We humans differ from nonhumans precisely in that our actions have *intentions* behind them, whereas the performances (behaviours) of quarks, microbes, and machine tools do not’ (Pickering, 1993 in Kaptelinin and Nardi, 2009, p. 238).

Alfred Gell’s anthropological theory of art, described in his book *Art and Agency* (Gell, 1998), proceeds in a similar direction. The theory attributes agency not only to people but also to works of art but, while artists can be defined as *primary agents* by virtue of being intentional beings, art objects are considered *secondary agents* that acquire their agency ‘once they become enmeshed in a texture of social relationships’ (Gell, 1998, p. 17).

Concepts related to the agency of things can also be found in the material culture research developed by the anthropologist Daniel Miller and summarized in his book *Stuff* (Miller, 2010). He argues that ‘in material culture we are concerned at least as much with how things make people as the other way around’ (Miller, 2010, p. 42). According to this view, things have a power, that of setting the scene or *frame*: they ‘make us aware of what is appropriate and inappropriate’ (Miller, 2010, p. 50). An interesting aspect Miller points out is what he calls the *humility of things*, the fact that things have more capacity to determine certain behaviours ‘the less we are aware of them’ (Miller, 2010, p. 50).

The design and interaction design literature also offers a rich store of reflections about the *agency* of things and their ability to act. The concept of agency is explicitly analysed in the work of Kaptelinin and Nardi (2009). Applying the principles of activity theory, the scholars propose a theoretical formulation that ‘retains the asymmetry of subject–object dichotomy’ (Kaptelinin and Nardi 2009, p. 251) by proposing ‘the notion of *levels of agency*, an understanding of agency as a dimension rather than a binary attribute’ (Kaptelinin and Nardi 2009, p. 247). In other words, different agents (i.e. natural or cultural things, natural or cultural nonhuman living beings, human beings, social entities) are characterized by different levels or types of agency, namely *conditional agency*, *need-based agency* and *delegated agency*. *Conditional agency* refers to the ability to produce

unintended effects and applies to any type of agent. *Need-based* agency refers instead to the agent's ability to act according to its own biological or cultural needs, and applies to human beings, higher animals and social entities, although in different ways due to the different nature of these entities. Finally, *delegated agency* refers to the ability of agents to 'realize the intentions' (Kaptelinin and Nardi 2009, p. 246) that are delegated to them 'by somebody or something else' (Kaptelinin and Nardi 2009, p. 248). Delegated agency applies to cultural things and living beings.

The design literature also implicitly contains other reflections on the agency of things, the ability of objects to determine specific behaviours in people and the role designers play in shaping the agency of things. For example, the notion of *affordance*, originated in ecological psychology (Gibson, 1977, 1979) and applied to design by Donald Norman (1988), suggests that, in order to design objects that are intuitive for people to use, designers should exploit 'the perceived or actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used' (Norman, 1988, p. 9).

Akrich develops another significant contribution in *The De-Description of Technical Objects* (Akrich, 1992) when he compares the role of the designer to that of a script writer conceiving of objects which, 'like a film script, [...] define a framework of actions together with the actors and the space in which they are supposed to act' (Akrich, 1992, p. 208). This is also connected to the concept of *persuasive design*, the idea that 'design can be seen as inherently persuasive and that objects can be understood as a kind of arguments in material form' (Redström, 2006, p. 121).

While the aforementioned contributions highlight the ability of design to shape the agency of objects and the behaviour of the people who will use them, some scholars also reflect on the fact that things do not always produce the intended effects. Divergence between intended and actual effects can occur because 'there is a certain dialogue going on: the designer proposes certain things through the designed thing and the user accepts, refutes or modifies these in relation to her own position. In practice results of such dialogue can be seen in the often-unpredictable discrepancies between intended and actual use' (Redström, 2006, p. 115). Similarly, Akrich points out that 'it may be that no actors will come forward to play the roles envisaged by the designer. Or users may define quite different roles of their own' (Akrich, 1992, p. 208).

Endorsing the general position of those theories that view the concept of agency as applying also to things (Latour, 1992; Gell, 1998; Miller, 2010;

Kaptelinin and Nardi, 2009; Norman, 1988; Akrich, 1992), the aim of this paper is to study the agency of tangible and embodied interaction systems applied to cultural heritage. In particular, taking the categorization of agency proposed by Kaptelinin and Nardi (2009) as starting point, we offer an initial exploration of the nature of these kinds of artefacts as a basis for laying out the specific objectives of the analysis. In doing so, we refer to the notions of levels of agency and types of agents proposed by the two scholars we have mentioned above. To conclude, we present some reflections as a basis for orienting future research.

Analysis of the agency of different categories of tangible and embodied interaction systems

Before analysing each category of tangible and embodied interaction systems, a reflection on the nature of these kinds of interfaces is required.

Following the categorization of agents and forms of agency proposed by Kaptelinin and Nardi (2009), tangible and embodied interaction systems can be interpreted as *Things*, namely *Cultural Things*, provided with *conditional* and *delegated agency*. Indeed, these systems are artefacts and, as such, they are not characterized by *need-based agency*.

Studying the agency of these things therefore means analysing their ability to realize – or not – the intentions of those who imagined, created and programmed them. But what are the intentions of designers?

Among the possible and varied intentions designers might have, in this paper we focus on two intentions we believe to be generally common to most kinds of interactive systems, namely: 1) the intention of designers to stimulate interaction with their systems; 2) the intention of designers to suggest the right behaviour for interacting with the systems and triggering their content. These aspects are analysed with reference to four paradigms of tangible interaction systems – (i) smart replicas/originals, (ii) symbolic objects (iii) codified gestures and (iv) performing gestures – with an eye to understanding how designers translate their intentions into the materiality of different categories of tangible interaction systems.

1) *smart replicas/originals*

The first category of tangible interaction systems includes projects that employ manipulable and sensorised original cultural assets or their copies to trigger digital interpretive content. By embedding sensors in the objects on

display, designers define the behaviour of the artefact and consequently seek to delineate the behaviour of the users who will manipulate it.

The specificity of the interactive systems in this category is that, being original cultural assets or their reproductions, they have a well-defined physical shape. Given this unique trait, the design intervention can only partially intervene on the physical appearance of the interactive objects and must focus primarily on what users can do and on what they consequently attain. Especially when dealing with smart originals, designers have the duty of communicating that touching is not only allowed but required, going beyond the unspoken rule that visitors must not touch objects in museums.

Indeed, these interactive originals/copies usually need to be handled, manipulated and sometimes touched to trigger digital interpretations. An example can be found in the temporary exhibition *Fragments of memory* that displays smart originals related to farming. By touching the exhibition assets, visitors can activate light effects and cause the objects to tell the stories of farmers, evoking the atmosphere of past times.

The agency of smart originals is not always clear, since the cultural asset on display does not necessarily ask to be touched and manipulated, especially if it pertains to the category of recognised artworks such as sculptures, paintings and bas-relief which are not usually accessible to visitors. Accordingly, designers enact strategies to trigger actions such as providing written instructions or catching visitors' attentions with sounds, light effects or video-mapping.

At other times, smart objects plainly declare themselves to be interactive systems. This is the case with smart replicas, which are usually different in size and/or material from the originals and have integrated sensors and buttons. An example of this is the VIRTEX presentation method (Capurro, Nollet and Pletincks, 2015), that uses 3D-printed scaled replicas of statues, buildings and objects to control the movements of a 3D model and buttons to start videos.

Although it is evident that these objects must be handled and touched, there is a different issue designers must cope with in that the effect of manipulation is not easily intelligible. Handling a replica of a statue does not necessarily mean activating videos, triggering audio descriptions or rotating a 3D model, and it is up to designers to help users understand what actions they must perform to trigger content and what they will obtain from manipulating the smart objects.

2) *symbolic objects*

The second category of tangible and embodied interaction systems uses the same mechanics as the first category – manipulating objects to trigger content – but the smart objects lose any formal reference to the objects on display. Accordingly, designers are empowered in that they can act on both the formal character of smart objects and the visitor behaviours triggered by these objects.

The projects included in this category are very diverse and adopt various strategies to trigger action. Some of them focus on the interactive object, treating it as the product of a design action and, as such, aim for high levels of communicativeness and easy handling.

Some of the objects produced by the above-cited meSch project (Petrelli et al., 2013b) follow this approach proposing co-designed smart objects. An example is *The Loupe* (Vaart and Damala, 2015), an augmented reality device masked as a magnifying lens that allows visitors to access interpretive digital content about the objects on display by using it as its shape suggests. In this case, designers rely on the evocative power of a universally recognised shape, that of the magnifying lens, to make people behave as planned, namely to look at the objects on display through the lens and activate interpretive content.

Other projects employ smart objects for their evocative power, that is, their significance in relation to the objects on display. The meSch project also offers an example of this: the exhibition *The Hague and the Atlantic Wall: War in the City of Peace* at the Museon in The Hague (Marshall et al., 2016), focused on the story of the Atlantic Wall and its impact on the city and its citizens told from three different viewpoints: Dutch civilians, Dutch civil servants and German soldiers. Six objects have been selected from among those on display to tell the three stories in Dutch and English: a tea bag (Dutch) and sugar packet (English) for the civilian, a travel pass (Dutch) and armband (English) for the civil servant and, finally, a drinking mug (Dutch) and dictionary (English) for the German soldier. Stories are triggered when visitors place copies of the objects, embedded with RFID tags, over pods. There is no formal difference between this kind of smart object and those in the first category – they are actually smart replicas – but they are employed for their evocative power and not as copies of artworks. From a design perspective, there is no difference between smart replicas and symbolic objects of this kind: the differentiation lies in the curatorial choice and the meaning-making ideally triggered by interaction.

Shifting the focus to the ability of these sensorised objects to prompt users to act “correctly”, we must note that visitors’ responses are not always straightforward. In analysing user interactions with the system, researchers from MeSch have found that not all visitors immediately grasped the correct mechanics of interaction even though instructions were clearly posted in both Dutch and English. The action of placing a mug or a travel pass on a pod, the hotspot, is not natural or embedded in the objects themselves.

3) codified gestures

The third category brings us into the world of embodied interaction, as it encompasses examples that employ gesture-based interaction to control and activate interpretive content about the objects on display.

For instance, explicit and codified movements captured by sensors are at the basis of the Gallery One exhibition by Local Project at the Cleveland Art Museum (Alexander, Barton and Gesser, 2013).

The *Sculpture Lens* installation works by capturing the facial expressions of visitor and showing artworks with similar expressions, while *Strike the pose* asks visitors to assume the same pose as sculptures and paintings in the collection with the aim of achieving the most accurate pose.

In other cases, gestures lose any direct relation to the artwork and become a sort of alphabet understood by the computer. This is the case with *Etruscanning - Digital Encounters with the Regolini-Galassi Tomb*, which lets visitors move virtually within the tomb and experience a digital encounter with a highly realistic VII century B.C. construction by performing a list of codified gestures.

The designers’ role lies in defining what kind of gestures visitor should perform to trigger interpretive content or modify the state of the digital system, be they related to the object on display – as in *Gallery One* – or free gestures. Designers are in charge of the aesthetics of the interaction and the expressiveness of the gestures, using visitors’ bodies as an input system.

In the two projects described above, the agency of the interactive system is not well recognizable in that visitors only understand what to do after reading the instructions. There is a question about the ability of the system to easily communicate the gestures visitors must perform to obtain the desired action in the digital sphere, making them simply recognized, understood and remembered.

4) *performing gestures*

Gestures lose codification in the fourth category, *performing gestures*, which comprises projects that prompt visitors to perform bodily movements that are meaningful in relation to the assets on display.

Not related to an alphabet of codified gestures, these movements can be imbued with meaning and become representative and symbolic of a value connected to the artwork or cultural practices.

The *Drinking symposium* installation at the Allard Pierson Museum of Amsterdam exemplifies this category. Made of a wall projection representing virtual characters taking part in a drinking symposium in Ancient Greece, a 3D printed replica of a Greek drinking bowl (kylix) and a reproduction of a Greek daybed, it prompts users to sit on the bed and lift the kylix, both embedded with sensors. By lifting the kylix, visitors animate a virtual character that lifts his kylix, toasts and drinks wine. When the bowl is put down a woman in the virtual scene plays the flute, and when a visitor sits on the daybed one of the animated figures plays a game popular in ancient Greece (kottabos) by launching a drop of wine from his cup toward a stand in the middle of the room.

Designers are asked to go a step further than the role they play in the third category. They can define what gestures visitors will perform and, in addition, verify whether those actions are meaningful and add to the comprehension of the objects on display. On the contrary, they can begin analysing actions that might be meaningful for the asset and introduce them into the system.

The aforementioned installation clarifies this concept: the actions performed by visitors have roots in an ancient past and help them to grasp not only the aesthetic quality of the assets on display in the museum but also their intangible value, such as their use and significance as part of a ritual.

In this case the sensorised objects play an important role in suggesting to visitors what they can do, in an effort to overcome the limitations of the installations described in the third category. A daybed suggests the action of reclining and the kylix should invite people to lift it, assuming of course that visitors have the cultural background needed to easily grasp how ancient objects should be used or have been informed by bespoke paratextual apparatuses. As in the case studies discussed above, *The Drinking Symposium* triggers visitors' actions by means of labels and instructions, thereby enforcing the agency of the smart objects.

Discussion and Conclusions

The analysis of the four categories of tangible interaction presented above outlines and discusses diverse ways of affecting visitor behaviour and fostering interaction. Nevertheless, to shed light on the diversities and specificities of the four categories we need to consider in more depth *how* they achieve these effects.

All four kinds of embedded and embodied interaction systems have in common the presence of rich instructions that inform users how to behave to obtain the desired outcome. Indeed, the case studies presented above as representative of the different categories all involve a need to explicitly apprise visitors that interaction is possible and how to achieve it.

In fact, rich labels can be interpreted as a way of enforcing or substituting the agency of the interactive artefact and its effects on users.

In the first category – smart originals/replicas – instructions play the important role of telling visitors: “Please touch, interact and manipulate without fear”. In other words, labels act on visitors by triggering interaction, as the interactive objects are normally associated with visual contemplation alone.

Labels and instructions play a slightly different role in category two: they not only clarify the function of smart objects, they also modify visitors’ usual behaviour with known objects. The example of the mug to be placed on a pod is emblematic of this: without instructions, the mug does not necessarily ask to be placed in a specific spot.

Instructions play an even more central role in category three, since these systems lack objects that would somehow suggest actions. Instructions even become a sort of training aid in *Etruscanning*, modelling the correct gestures that will allow users to properly explore the virtual environment.

In the fourth category, we can distinguish between instructions that plainly communicate the actions to be performed (e.g. ‘pick me up’ in the *Drinking symposium*) and the paratextual apparatus aimed at providing visitors with background information about the meaning of the gesture they will perform.

This need for a rich paratextual apparatus characterising all the categories may seem to be a secondary aspect, but it may also be interpreted as a symptom of the fact that these systems are still in the initial stages of development. On the one hand, it may suggest the inexperience of visitors unused to interacting with these kinds of interactive artefacts.

On the other hand, it may also betray a certain naivety on the part of designers in creating tangible and embodied interactive systems. That is,

using text and explanations to clarify how an interactive system works might mean that designers, and interaction designers in particular, failed to correctly or fully exploit the persuasive power of design (Redström, 2006) and the agency of designed objects.

However, another possibility to consider is that systems based on embedded and embodied interaction cannot avoid the use of labels and/or a paratextual apparatus to guide users' actions.

This apparent weakness in such systems represents the starting point for a reflection on the role of designers in creating experiences based on tangible interaction. It is also the basis for future investigations aimed at shedding light on this point and defining guidelines for designers involved in the creation of such systems.

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