Physicality, spatial configuration and computational objects

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Introduction

This paper addresses physicality and the spatial configurational character of interactive technologies that are prevalent within HCI research. The primary issue being presented here is the inextricable link between the fundamental qualities of physicality and the spatial configuration of objects. Firstly, the question of what is meant by 'physicality' is discussed in terms of 'computational' and 'non-computational' objects, in which the importance of physicality's relationship with spatial configurations is described. Secondly, the impact interactive technologies can have upon spatial configuration—and thus physicality—is explored. Finally, the implications for design and HCI are very briefly considered.

Physicality and spatial configuration

What is physicality? We can start with a simple definition: the physicality of an object is shaped by the physical properties of that object.[1] Tactile and visual senses primarily inform this; in the case of a mug, the shape and material form the essence of the immediate sensory experience. Somewhere above these immediate, low-level senses of the object lie concepts such as Norman's "perceived affordances" [6], which attempt to capture the nature of medium-level reasoning about an object's physical nature. Such notions consider all the perceived actionable properties of an object, such as how a thing is used as in the possibilities afforded by a mug's handle or a pen's clicker. There also is higher-level, non-sensory information that helps shape physicality, such as attributed or historical meanings and the aesthetic qualities of an object. For example, affordances and sensory data alone cannot inform someone how an object may be commonly used (e.g., musical instruments, religious objects, etc.), and as such one's historical experience or education about an object as well as a common sense, "what anyone knows" body of knowledge associated with an object both in turn further shape the experience of physicality. It is worth noting that this perspective on physicality is admittedly reductionist and abstracted and in that sense is most useful *as a metaphorical way of thinking* about physicality.

Why is it useful to understand what physicality is? Within the field of human-computer interaction, the physicality of objects that drive computation (namely, the physical manifestation of the computer, from the traditional mouse and keyboard to tangibles, handheld computers and mobile phones) differs from the physicality of everyday, non-computational objects. Computational objects have properties in addition to their sensable qualities, affordances and associated meanings and aesthetics. Some of these properties 'break' commonsense understandings of physicality. Computational objects have internal states that may change the resulting use of that object (the computational 'black box'), as well as interactive possibilities that are outside of the bounds of 'nor-

[1] By 'object' is meant things created by humans, rather than every possible object in the surrounding environment including plant matter, minerals and animals. Furthermore, in considering the properties of physical objects, a 'macro-level,' Newtonian sense of physicality as humans directly experience every day is assumed.

mal,' non-technological physicality (e.g., mobile phones and other objects that create action at-a-distance). (See [3] for a description of these properties.)

The physicality of computational and non-computational objects is, as has been hinted at already, intimately related to the spatial configuration of those objects in an environment and the spatial relations that exist between them. Here a couple of examples will be briefly turned to. Firstly we can consider the way in which knives and forks each have an individual physicality (e.g., the shape of them, their use in cutting or holding food, the historical use of knives and forks, etc.), and yet they also have a collected spatial configuration. There is a 'pairedness' and close proximity that is typically 'maintained' between knives and forks, such as in a draw or on a table. Knives and forks also have a particular relationship to other objects like the draw or the table. Umbrellas provide an instructive second example. They may reside indoors (on a stand) or outdoors, and have a configurational relationship with these outdoor and indoor spaces (i.e., the environment). It is of note that opening umbrellas indoors is traditionally thought of as 'unlucky' and thus it could be said that their use has different meanings according to the different configurations they operate in spatially.

Leading on from these examples, spatial configurations can be thought about in similar terms to the way that we have thought about physicality. Configurations have an immediate sensory impact (e.g., visual, tactile). They also have particular spatial affordances or actionable properties, such as how a particular arrangement of objects may afford certain movement/navigation or uses of a space (such as thoroughfare). Finally, these configurations can have associated meanings and aesthetics, such as the configurational meaning of objects in a church (for example, the cross and easterly orientation of a typical cathedral, or the open-plan or cubicle layout of a place of work). Since spatial configurations are configurations of physicalities, the sense, affordances and meanings of both are deeply tied together.

Figure 1 attempts to schematise the various different aspects discussed here.

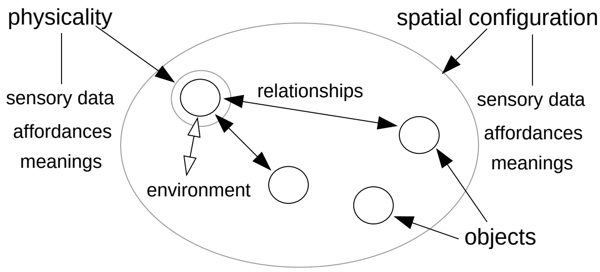

Figure 1: Physicality and spatial configuration

Computational objects and interactive technology

It is primarily the fundamental link between the spatial configuration of *technological* objects and the resulting impact upon physicality that is of interest in this paper. In order to understand how this change features for computational objects, we must consider technologies that have some link to the physical environment (i.e., the qualities of input and output).[2] This kind of interactive computational object is increasingly being included in mobile applications (such as games and tourist guides (e.g., [4, 1]), museum and gallery interactives (e.g., [7, 5]), and performances that are augmented or integrated with technology in some way (for many examples, see [9]). Technologies such as GPS, Wifi, ultrasonics, computer vision and RFID often feature in these examples. Such devices may have components embedded with physical units (e.g., PDAs or wearables) as well as those found in the environment (e.g., video cameras, GPS satellites, tag readers). These technologies often involve some form of instrumentation or sensing (e.g., sensing RFID tags, sensing the position of a fiducial marker, or sensing wireless network access points), and the appropriate interpretation of this data is typically vital to the function of the application it is driving. It is precisely when technology like this is placed in everyday environments ("in the wild") that their complex relationship with the environment and other computational and non-computational objects is exposed. These generated relationships are then essentially autochthonous in character and as such can only

[2]Whilst a computer with no input (e.g., keyboard) or output (e.g., display) is still a computational object, it is not of interest here.

be studied within the setting in which they were intended for, designed for, or actually used in. The point here is that HCI can potentially be informed by the broad study of these environments and thus in turn come to be informed about the nature of computational physicality and configuration as it shapes our everyday experience of technology.

There are many examples of this changed configurational and physical character, such as the way in which GPS coverage varies over both time and space. Certain objects in a space (such as buildings in a city) create 'shadows' that obscure a GPS unit from a satellite, rendering the unit's position information unreliable or unusable. This spatial character of the signal reception as experienced via the GPS unit also changes over time as the movement of satellites affect the shadows' sizes and orientations [8]. Another everyday example would be a television remote. The sensors and emitters (i.e., infrared) for such a system require that the remote maintains a particular spatial configuration with the television, namely close enough to it for the beam to be detected (a 'pairedness'). Having a remote in a hallway when the television is in your living room does not make sense for its use; the remote might be said to be "in the wrong place," and thus its physical meaning is shaped by its spatial configuration with reference to other objects. There are further examples from the technologies previously mentioned, such as: patchy and irregular coverage for Wifi access points; sonic interference in ultrasonic positioning systems (e.g., jingling keys or coins); and computer vision suffering from occluded or noisy images, resulting in problems, say, detecting fiducial markers.

In understanding the impact of introducing such instrumented or sensor-based technologies into real world spaces, it is perhaps useful for designers and technologists to consider the 'superimposed' character generated by the interaction of spatial configuration between objects and the environment, as well as the changed sense of physicality of the objects. Use of these technologies particularly in ubiquitous computing contexts is creating wholly new spaces. Returning to our examples, the television remote's technology transforms it into a useful object and yet at the same time restricts its physical meaning by establishing a relationship with television itself, just as the GPS unit's meaning and usefulness is bound by its technological components, i.e., by its relation to satellites via electromagnetic waves. So, whilst non-computational objects usually have their own configurational and physical meanings—such as an umbrella's relationship to the environment, or the pairedness of knives and forks—computational objects, or at least interactive technologies, have physicalities and configurations that can be deeply affected and shaped by their integral computational features.

Design for physicalities and configurations

How can we design for the changing spaces and physicalities presented by areas such as ubiquitous computing and other programs of research in which sensor-based or instrumented technology ? What the previous discussion has suggested is that designers can employ a few strategies when dealing with configurations and physicalities in order to shape interaction. Considering, for example, the spaces and configurations of those spaces in which interaction is 'safe' or 'unsafe' may be particularly useful when working with sensor technology. The designer of interactive systems involving computer vision, GPS or ultrasonics for example, may wish to guide users around or away from spaces in which coverage is poor, or interference with sensors is possible. Alternatively the nature and structure of this 'safe' and 'unsafe' configuration and physicality could be exposed to users in a legible and reasonable way, instead of treating these as 'bugs' or 'glitches' to be avoided. This can be seen as being a 'seamful' form of design [2].

A challenge for the HCI community currently, then, is to further explore and document the real-world implications of physicality and spatial configuration upon the increasing use of interactive technology in performance scenarios, museums, galleries and other public spaces.

Conclusion

This paper has proposed that physicality and spatial configuration for arbitrary objects is intimately linked. Computational objects, particularly interactive technologies, change the nature of this physicality and spatial configuration. Primarily this paper has attempted to assert that design for physicality should also be about design for spatial configurations.

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