

Metaphors of Physicality In Interaction Design

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Abstract

The technology behind Mixed Reality has advanced quickly and is set for adoption into the mainstream consumer market. Yet no sufficient interaction models have emerged in this field. Current models are ill suited to the medium, having primarily mimicked the 2-dimensional interfaces of the desktop world, simply projecting them in 3-dimensional space instead of creating interactions more suitable to the medium. The lack of practical interaction methods in this medium represents a barrier to mainstream adoption. As designers have created new forms of interactive media, each generation has abstracted the physical metaphors of the last generation. Continued abstraction of previous UI paradigms through metaphor is unsustainable and insufficient. In this paper, I explore the role of metaphor in interaction design, arguing that metaphor is inherent in all human communication, including visual languages. I then detail how each new interaction medium draws upon metaphors from the previous generation of technology, creating unnecessary complexity and labored interactions. Lastly, I explore what values a more intuitive interaction model might be based upon, urging models based on more intrinsic methods of human communication. These models provide a basis for interaction better suited to the medium, helping to advance mixed reality from its current state as a niche technology to a viable primary mode of interaction and communication.

Introduction

Metaphor is a fundamental tool in human communication. It works by equating two things, transferring meaning between them. We use metaphors to learn about unfamiliar concepts, using comparison to reapply existing knowledge to a new subject (Dix et al. 1998). As in spoken and written media, interactive media relies on metaphor as a core means of communication. In

mixed reality, direct metaphors of physical interaction are essential in creating learnable and usable products (Hackos and Redish 1998).

Metaphors in user interfaces create a bridge between what is understood and what is novel. In software, metaphors exist to help users construct a mental model of how to interact through analogy. By borrowing meaning from other contexts, users are saved the mental energy of understanding an interface from the fundamental concepts of the system (Lackoff and Johnson, 1980). As Weinschenk summarizes, "Metaphors are the tools we use to link highly technical, complex software with the user's everyday world." (Weinschenk et al. 1998). With repeated use, these metaphors become convention, further reducing the burden of learning new tools.

Both linguistically and visually, metaphors are not literally true. When designers use metaphor, an imperfect abstraction of the original meaning is created in the new context. In reusing meaning from another context, the original meaning is abstracted, losing clarity as if run through a copy machine. The meaning may be useful, but the transferred model cannot communicate directly because it refers to something that is not literally true in the new context. Metaphor usually requires a tradeoff between learnability and usability by imperfectly transferring meaning to a new context, leaving an easily created mental model that does not represent the true model of interaction.

Take the example of the file folder metaphor. This references the paper file folder, a physical place for keeping a collection of related items. The digital version of a folder serves much the same purpose as a location for storing things, with an icon as a visual metaphor to reinforce the organizational metaphor. Even text labels and color coding are features borrowed from a physical medium.

By copying previously understood meaning and applying it to a new context, new interfaces can be quickly learned by analogy, rather than by first principles. This ease in learnability is desirable when a perfect analogy is not required and an imprecise metaphor will suffice.

Similarly, the trash/recycle bin metaphor communicates a place for a certain

class of objects, and is filled up with those objects in a manner identical to the original waste receptacles. By necessity, this metaphor borrows all of the meaning of the original waste receptacles, but only uses some of that meaning. The idea of literally throwing trash out, or sorting our files into a recycling bin is meaningless in this context. The trash and recycle bins represent only a place to keep files before permanent disposal, yet require the cognitive overhead of a more detailed metaphor.

In the above examples, as in most metaphors in user interfaces, an element of physicality is included. Physical metaphors are familiar, concrete, and intuitive, which makes them well suited to transferring meaning to a new context. Information does not have the materiality to be manipulated, yet we must find ways to manipulate it.

As I will show, a consistent pattern has emerged in metaphor use: With new forms of interactive media, each generation has abstracted the physical metaphors of the last generation. Continued abstraction of previous UI paradigms through metaphor is unsustainable and insufficient.

With the rise of mixed reality, this abstraction becomes especially problematic. Mixed reality is different than previous transitions between media in that it breaks from the 2-dimensional models of understanding that have dominated the field for 60 years. With that break into three dimensions, interaction designers must must reconsider and ultimately abandon a reliance on 2-dimensional metaphors, creating new conceptual models based on more direct metaphors of space and physicality that more closely match our intrinsic methods of human communication.

The Pervasive Nature of Metaphor

Existing writings comprise much disagreement on the value of metaphor. It has been described as both a “golden rule” and as “fundamentally pointless.” (Blackwell 2006). Gasset praises its intrinsic nature, stating “Its efficacy verges on magic, and it seems a tool for creation which God forgot inside one of His creatures when He made him” (Ortega y Gasset 1948). Yet metaphor can create a distraction that harms designs, to the extent that Alan Cooper advises “Searching for that magic metaphor is one of the biggest mistakes you can make in user interface design” (Cooper 1995).

Though at times embattled within the HCI community, metaphor has been a persistent aspect of written works since their invention. Ancient philosophers regarded metaphor as a way to make one term stand for another, especially when there is no established term for what is being spoken about (Hills 2016). Given the ongoing generation of novelty in interface design, the continued use of metaphor in other forms of human communication appears inevitable.

In recent memory, metaphor has often taken the form of skeuomorphism, the use of materials like green felt and stitched leather being used in digital user interfaces. Though this form of visual metaphor has rightfully fallen out of favor, conceptual metaphors persist as useful tools for understanding new situations.

Metaphor is how we apply meaning that is already understood to a new context. In both written language and user interfaces, metaphor is an essential communication tool that is not a problem in and of itself. We rely on this transfer of meaning to make new tasks easier to learn. The problem arises from the way that metaphors are often copied and abstracted, eventually being stripped of all meaning, creating an interface that is burdened by complex metaphors that add cognitive overhead without aiding communication.

Abstraction in User Interface Metaphors

To illustrate this problem, I present the following hierarchy of abstraction in metaphors. This diagram details how each technological medium initially borrows and abstracts metaphors from the previous generation of technology. Some abstracted metaphors are abandoned in favor of more direct metaphors as the medium matures, but many are retained. The result is not only continued use of abstracted metaphors, but with them a continuation of the user interface elements themselves. Particularly relevant is the physical aspect of the metaphors in use, as this is often the most drastically abstracted feature when transferring between media.

Hierarchy of Abstraction in Metaphors

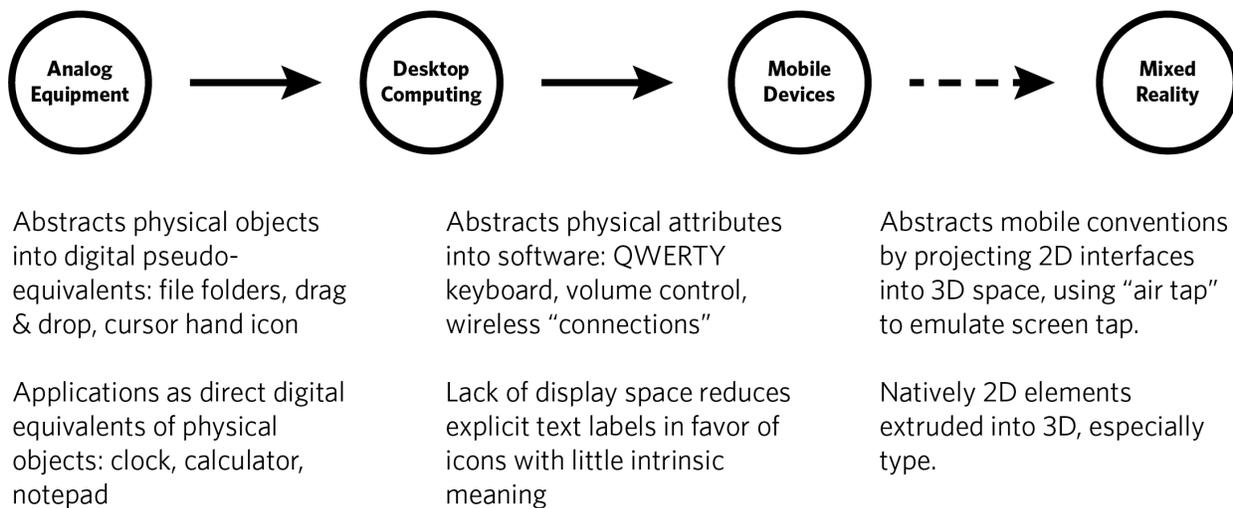


Figure 1: Hierarchy of Abstraction in Metaphors

In this way, each generation of technology abstracts the metaphors of the previous generation by adapting a part of its cognitive model, particularly those of physical interaction. It has helped each new technological platform become commercially viable by increasing familiarity. The use of familiar interaction patterns through metaphors enables leaps in technological media, yet this pattern also illustrates recurring dysfunction in design through repeated abstraction.

Signs and Symbols

With the introduction of the cassette tape to a consumer market, a new system of symbols was adopted to communicate operation. These media controls are the familiar, play, stop, and fast forward symbols that we encounter daily. The play symbol initially uses a metaphor of the winding of tape reels, a direct manipulation of the physical machinery that played the media. The fast forward symbol was a doubling of the play symbol, signifying winding of the reels at a faster speed.



Figure 2: Play and fast forward media controls

CD players were brought to market using the same symbols to represent different functionality. When applied to a digital medium, the concepts of playing the audio media remained somewhat the same, but no longer referred to the physical operation of the machinery. Additionally, while fast forward was retained, it was supplanted by the next track symbol and functionality. This symbol slightly altered the symbol for fast forward, indicating a fast forward to a specific point at the beginning of the next track.

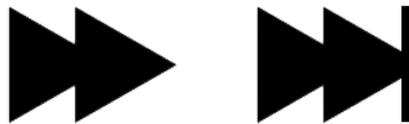


Figure 3: Fast forward and next media controls

As media consumption transitioned to desktop computers, it copied the existing metaphors of physical operation as well. As with the CD player, the concepts remained similar, but the operation was fundamentally different. These commands no longer represented the control of physical machinery, but the direct control of the resulting media, with the underlying computer mechanisms left to complete the operation.

The Problem With Abstraction

With the loss of direct control over the machinery that renders the media, these symbols lost any inherent meaning. They now communicate little relationship to the original idea of operation, instead becoming signs, meaningful only by familiarity and agreed meaning (Saussure 1986). At this point, the metaphor of physical operation of machinery has lost its inherent communication value. When no connection between previously understood concepts and the concept to be communicated can be made, the very purpose of metaphor is lost.

Metaphors are often reused through multiple generations of technological media. With repeated abstraction, the metaphor no longer represents the original idea, no longer communicates that idea, and serves only as a sign with agreed upon meaning, rather than inherent meaning. This defeats the communicative purpose

of using a metaphor, failing to deliver the intended level of communication.

This pattern of repeated abstraction of metaphors from previous technological media is insufficient. To create effective new forms of media, designers must create interactions from more direct metaphors that are more closely related to the intrinsic benefits of their medium.

In addition to a shortcoming in communication, the reuse and abstraction of a metaphorical interface element is often more complex than necessary, creating an additional gap in usability. For example, much early work in augmented reality relies upon projecting traditional 2-dimensional interfaces onto a 3-dimensional plane in space. By abstracting the 2-dimensional UI into a 3-dimensional object, understanding and ease of interaction both suffer. Users understand how to click buttons from prior experience, but the ease of pointing and the physical effort of holding one's arm up both create a more difficult interaction than a desktop interface.

Meanwhile, the opportunities of a 3-dimensional environment have been neglected, failing to make use of the more direct metaphor of manipulating digital objects in the same manner as physical objects. The original metaphors carried over from the 2-dimensional interface provide some benefit in understanding, but not to the degree of a more direct metaphor inherent to the new medium.

Additionally, interactions using small, unaimed gestures are a more direct and ergonomic means of interaction than the whole-arm gestures found in these early manifestations. The desire to emulate a mouse and cursor in a new medium misses an opportunity to create a superior means of interaction. This tendency to abstract previous interface metaphors is a crutch that prevents more fitting solutions from being developed.

Take the example of the Magic Cap interface, pictured below. This was part of an early touch based mobile device. It relies on a rather direct metaphor of office equipment to represent software tools that serve the same roles.

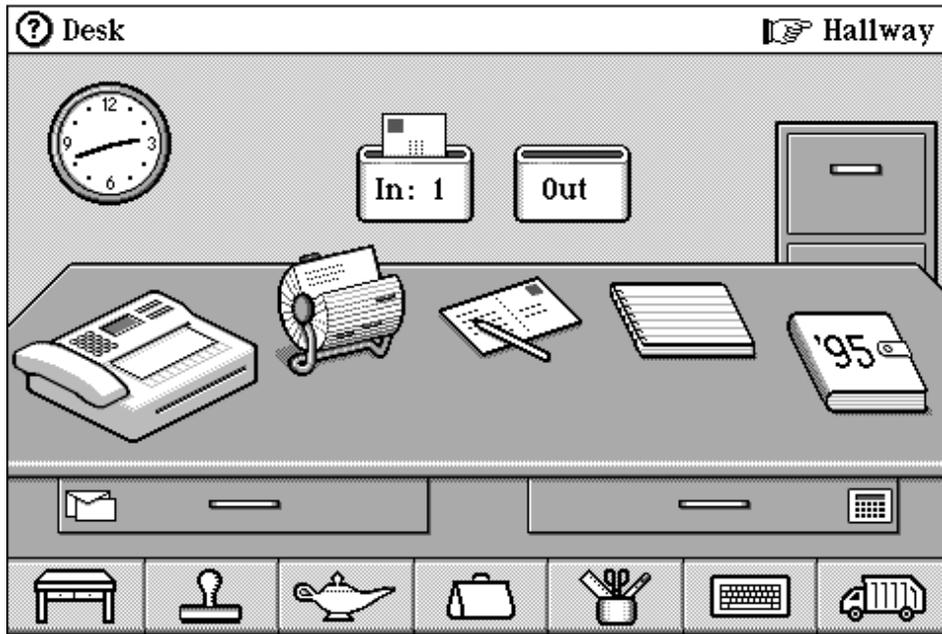


Figure 4: Magic Cap home screen, Kuniavsky 2010

As archaic as this interface feels today, it represents only one level of abstraction, from physical to digital. When 2-dimensional interfaces appear in 3D media, it takes existing abstractions like the above example and adds yet another layer of abstraction in bringing them back into a 3-dimensional space. This lends familiarity, but is ultimately more difficult to understand and use. The image below from Microsoft's Hololens demo is an example of such abstraction.



Figure 5: Hololens Demonstration Render

The Hololens example above is no less cumbersome than the previous example from the Magic Cap. Where the Magic Cap has abstracted physical items into a two dimensional interface, the hololens example is in fact more problematic because it begins with a 2D abstraction and creates an additional layer of abstraction in 3D. Mixed reality melds the real and the digital more closely than any medium before it. It only adds complexity to take a physical, 3-dimensional metaphor found in 2D interfaces, then abstract it back into three dimensions.

Metaphor in interface design provides clear utility in communication by applying existing knowledge to new contexts. It is primarily through repeated abstraction into new media that issues of metaphor in interaction design arise. Given these issues, how should interaction designers proceed in today's new media of mixed reality? This begins by using metaphors that closely match their medium while avoiding further abstractions of existing media.

Avoiding Another Generation of Abstraction

As the interface conventions of mixed reality are established, interaction designers should avoid another generation of abstracted metaphors. Instead, designers should draw more direct metaphors from the physical environment to create an interaction language that enables more direct, natural interaction.

What would make a more direct, natural metaphor? Current abstractions of 2-dimensional media into 3D are only successful in that they are familiar, both for users and for designers. However cumbersome to use in 3D space, the idea of buttons and cursors are well understood. A superior approach would end the use of these 2-dimensional metaphors and place priority upon usability over familiarity. By drawing a metaphor not to familiar desktop and mobile conventions, but to interactions with physical objects, a clear and direct interaction model can be conveyed to users while simultaneously creating an interface that is easy to operate once familiar. This establishes familiarity by drawing not from traditional computing, but on the experience of the physical world. In this way, both learnability and usability are achieved.

Further strengthening the metaphor of physical objects in mixed reality interfaces, any solution should use gestures in the same way that we currently use gestures in human-human communication. This should not be a new set of symbols,

but should instead be derived from how our bodies communicate. For example, when we can't hear someone speaking, we often put a cupped hand to our ear. This represents a pre-linguistic meaning, as the cupped hand directly assists in hearing. To apply this metaphor to an interface, the cupped hand ought to relate to volume controls. A design in this form would abandon previous conceptions of volume control UI, instead drawing a direct metaphor to our most direct forms of communication.

Treating interface elements like physical objects takes advantage of our practiced ability to complete small physical actions. Muscle memory can become a more direct, even sub-perceptual means of interaction. The ease with which one types, after sufficient practice, is without thought. In situations where there are multiple ways to complete an action, the muscle-memory based option is often superior. Take the example of switching windows in a desktop operating system. Icons and mouse clicks are easy to understand, yet a quick Alt+Tab can be executed thoughtlessly. In this way, gesture is the more direct expression of intent.

Gaze is another intrinsic method of communication. It is an automatic expression of our locus of attention in the physical world, and natural to the point that we can use it to communicate without being consciously aware. While seldom used as a standalone communication method, when combined with a context, it is a specific, directional expression.

Combined with gaze, unaimed gesture can add another dimension to communication. With this class of gestures, aim and command are separate. With location specified by gaze, common gestures can communicate an action. This is how we use gesture with other people: gesture, such as a hand wave, combines with gaze to specify a target of the gesture. Even without a gesture, the act of walking and looking in a direction can be used to communicate intent, making it possible to navigate a crowd without running into another person.

Unaimed gesture and gaze is similar to a desktop and a cursor. Consider the right click context menu as an example. The right click specifies more actions and the location specifies which entity the actions should be performed on. Because touch interfaces generally only have taps and not right clicks, they must bundle command and context into one action. In mixed reality, it is tempting to abstract the limited model of interaction from current mobile devices, creating "air taps"

with an outstretched arm to mimic the tap of a mobile device. This would render less control than a more direct method of interaction that can aim (gaze) and command (gesture) with separate means that are each superior at their own task.

Mixed reality experiences might use gaze by combining it with gesture. Generic gestures could pair with the gaze to establish context, signifying specific meaning. A generic command signifying “dismiss,” when combined with a gaze at a specific object, could dismiss that particular object. This also allows gestures to be completed with ergonomic consideration, rather than being pointed in a potentially uncomfortable or unattainable direction.

Direct Metaphors

Metaphor is intrinsic to human communication and will continue to be used in new forms of interactive media. It is an essential tool for making interactive media learnable by applying existing knowledge to a new context.

Without metaphor, every interface would feel like a command line interface: direct, little abstraction, and powerful, yet a substantial burden to learn, with little transference of functions between tools.

The use of metaphor comes with tradeoffs. When the metaphor is unrelated to its context, as with excessively abstracted metaphors, it provides no communication value, while enforcing a cumbersome interaction model. The result is both poor learnability and poor usability.

Mixed reality is an emerging medium with critical differences from previous media. To avoid many of the problems inherent in metaphors, this is the right moment to reconsider the metaphors that designers use, and to create new metaphors that better reflect the interaction properties of a spatial medium.

The metaphors of the last generation are an inevitable default condition in any new technological medium. If this default is allowed to become convention in mainstream use, the medium’s communication ability will suffer in the long term.

The better course of action is to establish direct, natural metaphors early in this new medium’s development, ensuring the highest level of communication in the interaction of humans and their technology.

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