Reality-Based Interaction: Unifying the New Generation of Interaction Styles

Robert J.K. Jacob
Tufts University
Computer Science
161 College Ave.
Medford, Mass. 02155 USA
jacob@cs.tufts.edu

Audrey Girouard
Tufts University
Computer Science
audrey.girouard@tufts.edu

Leanne M. Hirshfield
Tufts University
Computer Science
leanne.miller@tufts.edu

Michael S. Horn
Tufts University
Computer Science
michael.horn@tufts.edu

Orit Shaer
Tufts University
Computer Science
oshaer@cs.tufts.edu

Erin Treacy Solovey
Tufts University
Computer Science
erin.treacy@tufts.edu

Jamie Zigelbaum
MIT Media Lab
Tangible Media Group
20 Ames St.
Cambridge, Mass. 02139 USA
zig@media.mit.edu

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Abstract
We are in the midst of an explosion of emerging human-computer interaction techniques that have redefined our understanding of both computers and interaction. We propose the notion of *Reality-Based Interaction* (RBI) as a unifying concept that ties together a large subset of these emerging interaction styles. Through RBI we are attempting to provide a framework that can be used to understand, compare, and relate current paths of HCI research. Viewing interaction through the lens of RBI can provide insights for designers and allows us to find gaps or opportunities for future development. Furthermore, we are using RBI to develop new evaluation techniques for features of emerging interfaces that are currently unquantifiable.

Keywords
Reality-Based Interaction, interaction styles, virtual reality, ubiquitous computing, tangible interfaces, next-generation interfaces, non-WIMP interfaces.

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces
H.1.2 [Models and Principles]: User/Machine Systems — human factors;

A partial list of emerging post-WIMP interaction styles:

- ubiquitous and pervasive computing
- handheld interaction
- tangible computing
- perceptual and affective computing
- speech and multi-modal interaction
- context-aware computing
- virtual reality
- mixed and augmented reality
- lightweight, tacit, or passive interaction

Introduction

Over the past two decades, HCI researchers have developed a broad range of new interfaces that diverge from the "window, icon, menu, pointing device" (WIMP) or Direct Manipulation interaction style (DM). Development of this new generation of post-WIMP interfaces has been fueled in part by advances in computer technology and by an improved understanding of human psychology. Defined by van Dam as interfaces "containing at least one interaction technique not dependent on classical 2D widgets such as menus and icons" [20], some examples of post-WIMP interaction styles are listed in the sidebar. Although some may see these interaction styles as disparate innovations proceeding on unrelated fronts, we propose that they share salient and important commonalities, which can help us understand, connect, and analyze them. First, they are designed to take advantage of users' well-entrenched skills and expectations about the real world. That is, interaction is becoming more *like the real world*. Second, these interaction styles are transforming interaction from a segregated activity taking place at a desk into a fluid, free-form activity that takes place in our everyday environment. That is, interaction takes place *in the real world*. In both cases, new interaction styles draw strength by building on users' pre-existing knowledge of the everyday, non-computer world to a much greater extent than before. We propose that these emerging interaction styles can be understood together as a new generation of HCI through the notion of Reality-Based Interaction (RBI). Viewing them through the lens of RBI can provide insights for designers, can uncover gaps or opportunities for future research, and may lead to the development of improved evaluation techniques.

Related Taxonomies and Frameworks

To date, work that attempts to explain or organize emerging styles of interaction has focused more on individual classes of interfaces than on ideas that unify several classes [4-7, 14, 19]. Some work has focused more generally on new issues that are not present in interactions with traditional WIMP interfaces [2, 3, 12]. Other work has focused on specific interaction styles based on reality [1, 16, 21]. While previous work focuses on a small subset of interaction styles, our RBI framework applies to a wider range of emerging interaction styles.

Finally, the work that helped define the GUI generation was an inspiration for our work. Shneiderman took a variety of what, at the time, seemed disparate new user interface inventions and brought them together by noting their common characteristics, defining them as a new generation of user interfaces (DM) [17]. Hutchins, Hollan and Norman went on to explain the power and success of these interfaces with a theoretical framework that provided a basic understanding of the new generation in human terms [8]. Our hope is to take the first step in that direction for the emerging generation of interaction styles.

Reality-Based Interaction

Interaction has evolved from the first generation of Command Line, to the second generation of Direct Manipulation, to the new generation of emerging interaction styles such as those described in the sidebar. We believe that this new generation is unified by an increased use of real world interactions over previous generations. By "real world", we mean the undigital world, including physical, social, and cultural reality outside of any form of computer interaction. We

figure 1. Emerging interaction styles are moving into the real world in ways that would have been impossible for the previous generation of graphical user interfaces.

figure 2. Virtual reality interfaces feature interactions that are *like* the real world.

introduce the term Reality-Based Interaction for emerging interaction styles that share this common feature. We have identified two overlapping classes of reality-based interactions: those that are embedded *in the real world*, and those that mimic or are *like the real world*. Both types of interactions leverage knowledge of the world that users already possess—for operating the user interface itself and/or for combining the interface with other tasks in the user's environment.

*Interactions **in** the Real World*
With ubiquitous, mobile interfaces, computation has moved out of the lab or office and into the greater world. While portability is a major part of this shift, both the integration of devices within the physical environment and the acquisition of input from the environment, serve as factors contributing to it as well.

*Interactions **like** the Real World*
As technology moves into the real world, we also observe that interactions are becoming more *like the real world* in that they leverage prior knowledge and abilities that users bring from their experiences in the real world. For example, virtual reality interfaces gain their strength by exploiting the user's perceptual and navigational abilities (Figure 2). Indeed, the idea of *transfer of knowledge*–that it is easier to transfer already learned skills to a new task rather than learning completely new skills–is well known in psychology literature [15]. Although the user may already know more arcane facts, such as pressing the Alt-F4 command to close a window on a desktop computer system, it seems intuitively better to exploit the more basic knowledge that the user obtained in childhood rather than exploiting less innate knowledge. Information that is deeply ingrained in the user, like navigational abilities, seems more robust, more highly practiced, and should take less effort to use than information learned recently. This "reality" measure in RBI is more of a continuous measure than a dichotomy.

Direct Manipulation interfaces also leverage these human features through the use of metaphors based on the real world including graphic icons, drag and drop, and folder systems [17]. DM moved user interfaces closer to realistic interaction with the computer; reality-based interaction simply pushes interfaces further in this direction, increasing the realism of the interface objects and allowing users to interact even more directly with them.

Implications for Design
We believe the trend toward more reality-based interaction is a positive one. Basing interaction on the real world can reduce the mental effort required to operate the system because the user is already skilled in those aspects of the system. For casual use, this reduction might speed learning. For use in situations involving information overload, time pressure, or stress, this reduction of overhead effort could conceivably improve performance.

However, simply making an interface as reality-based as possible is not sufficient. A useful interface will rarely entirely mimic the real world, but will necessarily include some "unrealistic" or artificial features and commands. In fact, much of the power of using computers comes from this "multiplier" effect, the ability to go beyond a precise imitation of the real world. We therefore propose a view that identifies some fraction of a user interface as based on realistic knowledge or abilities plus some other fraction that

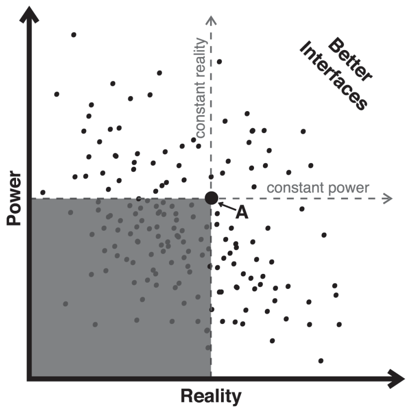

figure 3. *Power vs. Reality Tradeoff*: each datapoint represents a hypothetical interface. Consider the point marked A. The dashed horizontal line represents interfaces with equivalent power. The dashed vertical line represents interfaces with equivalent levels of reality. RBI suggests that adding reality to these interfaces without loss of power will make them better, and that giving up reality to gain power should be done carefully.

provides computer-only functionality that is not realistic. As a design approach or metric, the goal would be to make the first category as large as possible and use the second only as necessary.

For example, consider the character Superman. He walks around and behaves in many ways like a real man. He has some additional functions for which there is no analogy in real humans, such as flying and X-ray vision. When doing realistic things, he uses his real-world commands, walking, moving his head, looking around. But he still needs some additional non real-world commands for flying and X-ray vision, which allow him to perform tasks in a more efficient way, just like a computer provides extra power. In the design of a reality-based interface, we can go a step further and ask that these non real-world commands, be analogous to some realistic counterpart. For example, in a virtual reality interface, a system might track users' eye movements, using intense focus on an object as the command for X-ray vision [18].

We can thus divide the non-realistic part of the interface into degrees of realism (x-ray by focus vs. by menu pick). The goal of new interaction designers should be to allow the user to perform realistic tasks realistically, to provide additional non real-world functionality, and to use analogies for these commands whenever possible.

As illustrated in Figure 3, there is a tradeoff between power and reality. Here we refer to "power" as a generalization of functionality and efficiency. The goal is to give up reality only explicitly and only in return for increasing power. Consider an interface that is mapped to point A in Figure 3. If the interface is redesigned and moves to the upper left quadrant, its power would increase, but its reality would decrease, as often occurs in practice. According to RBI this is not necessarily bad, but it is a tradeoff that must be made thoughtfully and explicitly. The opposite tradeoff (more reality, less power) is made if the interface moves to the lower right quadrant. However, if the interface is redesigned and moves anywhere in the grey area, RBI theory claims that this interface would be worse, since both power and reality have been decreased. Similarly, moving anywhere in the top right quadrant is desirable, as it would make the interface better on both counts.

Returning to Superman, we should use a conventional walking gesture to walk—unless using a less natural command would provide extra power (speed, automatic route finding). The designer should not give up the reality of the walking command lightly, not without gaining some expressive power or efficiency.

Future Work

To perform experimental evaluations of the RBI framework, we are developing interfaces designed in different interaction styles and intended to differ primarily in their level of reality. We will conduct a study to determine the effects of each interaction style on users' time, accuracy, and attitudes while completing a given task. This can provide some quantitative measure of the effect of reality on the interaction.

Another important consideration for the new generation of HCI is how new interfaces themselves should be evaluated. At the CHI workshop, "What is the next generation of Human-Computer Interaction?" [10, 11] we brought together researchers from a range of emerging areas in HCI. A prevalent concern among the participants was that evaluation techniques for direct manipulation interfaces may be insufficient for the newly emerging generation. Many new interfaces claim to be "intuitive," which is often difficult to quantify, but listing and measuring the extent to which they use pieces of knowledge and skills that the user has acquired from the real world may help.

Furthermore, in addition to commonly used user interface measurements (e.g. speed and accuracy), other measurements such as workload, engagement, frustration, and fatigue may also be valuable for RBI. However, these measurements are generally only measured subjectively. More quantitative tools are needed. One recent study conducted by Lee and Tan [13] used EEG to monitor participants' brain activity while performing one of three mental tasks. By using a machine learning model, the researchers were able to predict the task being performed by monitoring extracted features from users' brain waves with over 75% accuracy.

Motivated by these findings, we use a relatively new non-invasive, lightweight brain imaging tool called functional near-infrared spectroscopy (fNIRs) to objectively measure workload and emotional state while completing a given task. This tool has been shown to quantitatively measure attention, working memory, target categorization, and problem solving [9]. We hypothesize that an objective measure of cognitive workload may prove useful for evaluating the intuitiveness of an interface. We further conjecture that reality-based interfaces will be associated with lower objective user frustration and workload than non reality-based systems.

Conclusion

We seek to advance the area of emerging interaction styles by providing a unifying framework that can be used to understand, compare and relate emerging interaction styles. We proposed the concept of reality-based interaction to characterize a large subset of the emerging generation of HCI. We identify two types of reality-based interactions: those that are in the real world and those that are like the real world. Based on this notion of reality-based interaction, we provided design considerations for reality-based interfaces. We are currently developing techniques for evaluating both the RBI framework and emerging interfaces. Viewing emerging generation interfaces through the lens of reality-based interaction allows us to focus on creating designs that leverage users' pre-existing skills and knowledge.

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