



Seminar
Post Desktop User Interfaces

Physics in the User Interface

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Abstract

When we think about physical science, many different phenomena emerge in mind: weather conditions, electricity at home, sound and light, motion and gravity. Indeed, so many things around us, so many events and occasions are tightly related to physics. Even in the virtual computer world we try to preserve physical rules. Thus, we add the natural harmony and vitality to digital interfaces.

It is not a secret that physical science is a fruitful field for UI designers. Different phenomena, object behavior and properties let us borrow interesting ideas from the real world and map them to the digital world. If we study some examples, we can find interesting discoveries how different physical branches are applied in the successful interfaces.

The common method to introduce physics to the user interfaces is the metaphor approach. The approach seems to work greatly if the user is familiar with the metaphor. However, some users could not have enough experience with the digitalized real life object, or they may expect from it more functionality than actually implemented. Moreover, the designers tend to stick to the widely integrated metaphors and restrict their fantasy to this limited design scope. In this paper we present some ways to improve the metaphor approach in order to overcome the mentioned problems.

Introduction

Physical science studies natural phenomena and the laws of nature. These different laws we observe every day in the surrounding world. Natural phenomena become so usual for us that the magic of physics vanishes in the everyday world. The challenge of the user interfaces is to simulate the natural environment in the digital world so that the natural harmony and vitality is preserved.

Physics: reflection in UI

Many different physical branches inspire UI designers to new creations. Here we should count on target user knowledge, the experience with a physical phenomenon that the user encounters often in the everyday life. Although most of the physical branches seem quite familiar to a user, there are still some special parts of physics that are not intuitively understood by an average user. And thus, they do not have any counterpart in the world of user interfaces. For example, the

modern physics chapters could be familiar only to the people specializing in this field. The rest wide auditorium of users has no or just very rough understanding of modern physics. Therefore, the phenomena and the rules of this physics part should be avoided in the user interfaces design.

In our paper we will discuss optics, electromagnetism, and mechanics branches, as these fields are quite familiar to a large group of UI users.

Optics

Vision is the most important source of information that delivers the greatest amount of information to human. Optics gives us an opportunity to exploit this source in the UI field in the different ways.

Simulation of lenses in user interfaces allows us to smartly highlight the necessary information in the larger size. For example, to view the current tasks in Mac OS, the icons on the task bar are magnified while pointing cursor over them (See Fig.1).



Figure 1 – Task Bar of Mac OS

Different optical effects also serve as a means to attract user's attention. For example, the monochrome shaded windows in the background “prompt” user to focus on the colored bright window in the front position. Similarly colors, brightness, contrast, and hue range tell us some information about the screen state and objects.

Visual effects like shadows, fades, blurring and others, add the vitality and naturalness to the interface appearance. 3D space organization, occlusions and object perspectives greatly influence the perception of the interface.

Zooming operation can be also referred to the optical branch of physics. Although it does not have any direct physical counterpart in the real life (we cannot zoom in and out images with an arbitrary factor), the prototype of zooming was taken from a magnifying glass concept. An interesting application of zooming function was introduced in [1] where user is able to zoom a drawing in and out with arbitrary precision. Moreover, the interface allows the user to zoom a specific part of an image while letting the remaining part stay unchanged.

Electromagnetism

Although this branch of physical science is probably not familiar in details to many users, the basic concepts of electricity and magnetism are mainly understood by the majority. Therefore, electromagnetism represents an interesting area of ideas for user interfaces.

For instance, the concept of electrical circuit is smartly employed in Quartz Composer, a visual programming tool for interface design (See Fig.2). Here the blocks define an information flow and the processing. They also serve as routers to connect the appropriate input and output lines in a desired way. This model acts exactly like an electrical circuit diagram would act: connected nodes trigger the electric current in the desired direction.

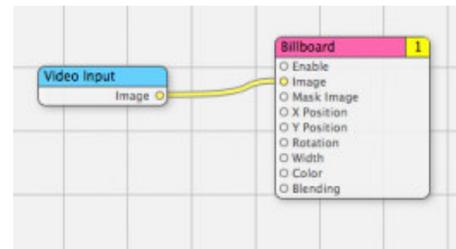


Figure 2 – Quartz Composer

The concept of magnetic field can be observed in many drawing applications in the mode called “Snap to Grid”. Here the grid of the field represents the analog of an attracting metal, and the objects of the drawing simulate magnets attracted by the “metal” grid. Even without a deep understanding of magnetism theory the user will be able to imply his life knowledge in this interface and easily find out how the snap function works.

Mechanics

Mechanical laws and principles can be observed in a good majority of modern user interfaces.

Consider motion as the most frequent mechanical phenomenon in the real life and the UI design world. One important property of motion is its smoothness and it has been shown to increase productivity [2] when used in user interfaces. Since processors nowadays can handle graphical computations in the real time as the user input is perceived, smooth transitions are implemented in standard desktop environments rather than objects “teleporting”. To make the motion even more realistic, the movement of an object might start at zero velocity and then accelerate and slow down before it reaches the endpoint. Some computers can use force effects to give feedback, this concept is widely used in computer games or in vibration alerts of cell phones.

Physics in Data Transfer

The properties of physical motion can be employed in user interface design for different purposes. In our paper we would like to draw attention to two applications for data transfer that exploit realistic motion and human gestures. Both inventions represent the ubiquitous systems supporting cooperative work of the user groups aiming to ease the data sharing and transportation between group members.

Toss-It

The first work, called "Toss-it" [3], represents a prototype of a system that enables users to share data by means of PDAs. The authors imagined a group of people working in one room with their PDAs and implemented a simple and fast method for sending a file from one user to the other user(s), or even to a device, e.g. a printer. To send a file to a specific person or a specific device the user has to make a throwing gesture with his PDA, so that the end of the transfer trajectory leads to the specific target (See Fig. 3).

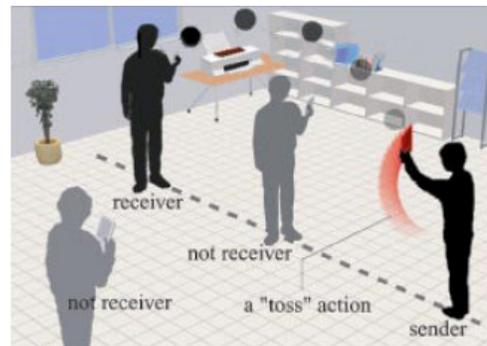


Figure 3 – Toss-It data transfer

To send the file to several people at once the user makes a "swing" gesture that specifies an angle so that all recipients within this angle get the file.

This method works without setting up a network connection manually and navigation through menus on the PDA screen, but all necessary input to specify the transport and the targets is expressed in a single move by the user. This action makes good use of the mobile nature of the PDA and avoids interaction on the device, which would be limited by the small screen space and in most cases would take more time and steps to set up the network connection. By contrast, the transport action for a digital document becomes for the user more like a natural transportation of a real object. Furthermore, sharing data with many persons at the same time becomes even faster than it happens with real documents.

During the user tests the current implementation showed lacks in accuracy and achieved success rates of typically 75%. To improve this apart from the technical aspect the authors suggested exploiting contextual information, for example a catching gesture to express the intention to receive data.

i-LAND

This prototype simulates an interactive room in CSCW environment.[4] The idea of the project was to help a team with innovative and challenging tasks, while the team members regroup themselves depending on the actual tasks.

Among interactive computer enhanced chairs and table, the room ware provides an interactive wall DynaWall. The developers of i-LAND have implemented several modes to transport data using this touch-sensitive interactive wall. The first mode, called "tossing", enables a wall user to send an object displayed on one part of the wall screen to some other part of the wall screen, by means of the throwing gesture.



Figure 4 – “Tossing” mode

"Take and put" mode represents a method to pick content with a dragging gesture and place it at some other position with a dropping gesture. This mode was inspired by previous research done by Rekimoto [5], whose "pick and drop" metaphor featured movement of content between different computers with the use of a digital pen.

These two interaction modes improve the way of data transfer, as they propose an alternative to the stressful traditional content movement over the full screen size, by holding down a mouse button (or another pointer) and walking over to the endpoint.

Another interesting finding of the “i-LAND” project is the method to transport content between the different devices. This concept is called the "passage". The "passenger" is a physical object (e.g. a block of wood) that a device can virtually store the information on. The content moves along with the object to the new location on the interactive table. The identification of the object is achieved via its weight. Similar to "toss-it" project [3] the user does not have to care about the setup of the network connection, but specifies source and target with the natural interactions with the system. Thus, the realistic gestures and motions ease the interaction with the digital content.

Metaphor Approach

Why does the physics science attract UI designers so much? First of all, it is a fruitful field for design ideas. One just needs to look around to find interesting concepts to borrow for a user interface. Simulation of physical phenomena can add more life to an application, enhance interactivity. Physical objects give designers important hints about their properties and behavior that can be further implemented in the user interface.

Moreover, physically-inspired designs map our natural environment to the digital world. This extends the range of the potential users and makes the application more understandable and usable.

The common method to introduce physics in a user interface is called “Metaphor approach”. In this case a designer takes a real life object as an inspiration and implements its counterpart in the user interface. Thus, the concept of the real world is smartly transferred to the virtual digital world. The user imports his experience of the real-life object into the digital counterpart and gets an idea how to operate the UI.

It seems that the “Metaphor approach” works perfectly. Indeed, in the current IT world there are many such metaphors widely integrated in our life. As examples we can mention Files, Windows and Desktops that even seem to belong to the digital world much more than to the real one!

However, the “Metaphor approach” can be considered both helpful and harmful. On the one hand, it uses the analogies with the natural objects, thus increasing user’s understanding and shortening the learning phase. Moreover, the training time would be significantly improved for such interfaces. Physical properties of the real-life objects can be mapped to the UI items providing the clear natural affordances. If the user has some experience with the real-world’s counterpart of the metaphor, it will not be a problem for him to understand the meaning and functionality of the appropriate UI item. Finally, the widely spread and accepted metaphors become in some sense the UI standards. Users are getting used to them so much that they decline the possible alternatives even if they notice some discomfort while using these standard UIs. Here we can speak about the ubiquity of the widely integrated UIs.

Despite these certain arguments, there are some disadvantages of the “Metaphor approach”. First of all, we cannot speak about the universal metaphor. If some people are familiar with the real-life counterpart of the UI item, the others can have

no experience with it at all, due to the cultural, ethnological, or some other differences. Second, the user, knowing well the physical base of the metaphor, can import more knowledge in its UI counterpart. As a result, the user will expect much more functionality than actually implemented. The lack of this functionality will lead to confusion and frustration of the user. Finally, the fact of wide acceptance of standard metaphors can cause the dangerous limitation of the designers' fantasy. When sticking to the discovered successful metaphor, as e.g. the flat desktop (See Fig.5), we slowly stop thinking about the possible alternatives.



Figure 5 – Similarities in Desktop implementation in MS Windows and Mac OS

This imagination restriction can seriously block the further innovations and revolutionary solutions in the UI Design world.

To avoid this process we introduce in our paper some possible improvements of the “Metaphor approach” that help to solve this problem:

1. Add more physics to the existing metaphor-based UI
2. Take a fresh look on the real-life counterparts of metaphors
3. Augment physical properties of the real-life metaphor counterparts

These approaches seem to be quite similar at first glance. However, they differ mostly in the time point when they are applied and the target object for change. While first method takes the implemented UI as the base, and changes only its particular component, the second and the third methods start the UI design from scratch and implement the metaphor in the new way. Let us have a look at these methods in more details and illustrate them with examples.

Adding more physics to existing metaphor-based UI

This method proposes taking an existing user interface as a base and extends physical properties of the particular component of this interface. The extension can be performed as feedback enrichment, extra functionality or additional behavior making the UI more natural and giving the existing component vitality.

A good example for this method is “The SonicFinder” [6]. This work was inspired by the idea that the sound should be used in computers as it is in the real world, where it conveys information about the nature of sound-producing events. In SonicFinder information is conveyed using auditory icons which are everyday sounds meant to convey information about computer events. Such icons represent an intuitively accessible way to use sound to provide multidimensional, organized information to users. For instance, selection event is accompanied with the hitting sound, dragging event – the scratching sound. Similarly, the file type (application, folder, disk) is mapped to the specific material sound. So, the actions under an application are accompanied with the metal sound, the actions under a file – with the wood sound, etc. Therefore, SonicFinder interface provides both auditory and standard graphical feedback to users.

Another example of the physically enhanced interface is the “Looking Glass” of Sun Microsystems [7]. Here the standard desktop elements (windows, icons) can be organized in 3D space (See Fig. 6). Thus, several running applications can be viewed simultaneously. The interface also offers some features like the 3D jukebox for realistic browsing of available movies. An interesting finding of “Looking Glass” is the possibility to make notes on the reverse side of the window. The designers represented a window as a physical flat object that naturally has two sides, one interactive, executing the current task, and the other one is used for notes.



Figure 6 – Looking Glass

Fresh look at the real-life counterparts of metaphors

According to this approach the designer revises a standard metaphor (e.g. Desktop), and implements an innovative UI, dissimilar to many standard existing ones.

An interesting example for this method is “BumpTop” interface [8]. Here the authors took the usual desktop metaphor and implemented it in the 3D version.

Designers analyzed the common routines and procedures in the real-world desktop and realized that it is more convenient to organize files casually in piles. They swerved from the standard flat desktops and folders. In BumpTop the user data are structured in piles that allow natural interactions similar to those happening in the usual desktop. By means of the pointer user can toss the piles, add some documents into them, browse, scatter the pile, etc. The 3D desktop surface is tiled

by 25% to the camera, on this surface all documents are represented as icons (See Fig.7). These icons are 3D boxes whose movement is simulated with physical laws: each icon has a corresponding mass, accelerates when moved, can collide with other icons and push them around. Gravity force pushes icons on the desktop surface and when a selection of icons is moved together springs are created in between, so that their spatial relationship is maintained. This gives a user much more expressiveness to arrange the icons with a meaning, similar to piles in office desktops. Some of the physical laws were relaxed, for example it is not possible to knock a pile over when hitting it while moving an icon.



Figure 7 – BumpTop desktop

User evaluations show that the majority of users found the interface very entertaining, satisfying and fun. However, the selecting of the scattered files and some other selection modes caused the difficulties for users. Important to mention, that the interface has some limitations in scaling: when the number or the size of files gets larger, the interface runs into problems.

In spite of these imperfections, the BumpTop project represents a real innovative approach to the desktop interface that employs the natural use of the real-life object.

Augment physical properties of the real-life metaphor counterparts

This approach suggests a designer to take the real-life object and implement its digital UI counterpart that has more functionality and augmented properties.

A good illustration for this method is the “PaperWindows” of David Holman et al. [9]. The inspiration for this work was the idea of merging the physical and digital worlds. The authors took a sheet of paper as the metaphor and gave it the functionality that real paper does not support: the digital paper window is able to copy the content from the screen, browse, scroll the pages, etc. In this case the physical shape of paper is digitally utilized. The interaction with the digital paper happens in the 3D space. User’s gestures are analyzed by the system and used to control the interaction. User’s fingers are equipped by sensors that let user to perform different actions. E.g. the rubbing gesture allows user to transfer content from screen to paper window or from one paper window to another. With flipping

gesture user can scroll through document pages or navigate to the next page of document.

Another interesting project using augmenting approach is the “Bulletin Board” [10]. This novel interface presents the interactive content on public digital bulletin boards. Inspired by paper fliers on physical bulletin boards, posted content is displayed using 3D virtual fliers attached to a virtual corkboard by virtual pushpins. Fliers appear in different orientations, creative an attractive, informal look, and have autonomous behavior like fluttering in the wind. Passerby can rotate, move and fold fliers. They can also interact with fliers’ life content. Therefore the digital bulletin board offers more functionality than a physical bulletin board.

User study suggested that the physical representation was very attracting and users were quite appealed to use it. However, some problems were also mentioned: The absence of collision detection was implemented to ensure real time animation, so fliers were able to pass though each other. This break in the physical metaphor seemed weird and unnatural to some users.

Conclusion

In the world of user interfaces we can find many applications of physical science. Among intuitive mechanical, optical and acoustical laws, one can see the electricity concepts and magnetism phenomena involved in UI design. Physical world offers many ideas to borrow for the sake of a successful and natural user interface. The common inspiration for the designers is the real-world metaphors. Such metaphor can map the behavior and properties of the real object to its digital UI counterpart. Many examples in modern interfaces prove the success of the metaphor approach. However, there are some drawbacks in such wide acceptance of the successful metaphor-based UIs. The main danger here is represented by possible restriction of the designer’s ideas that are bound to the standard metaphors. We offered three possible improvements of the metaphor approach that can resolve this limitation and give some ideas for new interfaces implementation. First of them suggests extension of particular standard components in existing metaphor-based UIs. Second method proposes designers to revise the successful real-life counterpart of metaphor and create innovative design based on the metaphor. The third method augments the physical properties and behavior of a real-life object and implements the UI counterpart with augmented possibilities.

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