Affordances for Direct Manipulation in Interactive Environments

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Figure 1: In the desktop environment classical GUIs rely on visual cues and metaphors in order to suggest the interaction operated with mouse and keyboard on digital information. In the physical environment objects provide affordances for manipulation. Affordances for hybrid information in mixed reality need to be designed for users' construction of an interaction conceptual model.

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Abstract
Interactive environments encounter the presence of different types of displays, supporting different activities and the interaction of different users. The conceptual model of direct manipulation assumes novel aspects in such a setting, thus requiring novel GUIs for the creation of affordances for hybrid interaction (i.e., across physical and digital information). Hereby I present some examples where I apply such a concept.

ACM Classification Keywords
H5.2. Information interfaces and presentation: User Interfaces. – Graphical User Interfaces.

Motivation
The emergence of ubiquitous computing scenarios promises to bring digital information on the walls of everyday life environments, embedding computing and displaying capabilities within the physical space and the material artifacts which populate it. In such interactive environments, where people can move around in a display continuum rather then sit at a desktop behind their screens, handle physical as well as digital objects at the same time and interact on shared displays in co-located or remote collaboration, the WIMP interaction paradigm comes short in supporting users' interactions. Although talking about direct manipulation, in the

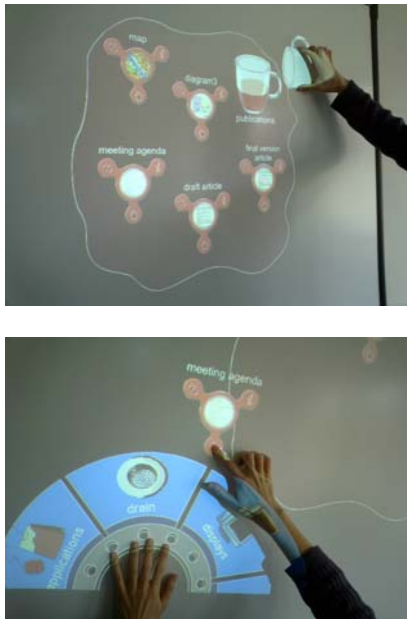

Figure 2: The dominant hand, e.g. the right one, is devoted to the manipulation and navigation of information. The non-dominant hand, e.g. the left one, works as command invocation, managing a menu of resources (e.g. drain, displays, printers). Such menu can be scrolled with a movement of the finger on a holed gear, which makes the circle segments rotate. The dominant hand moves units of information to the preferred resource.

desktop environment we mostly need input devices, such as mice, track pads or joysticks, to interact with the system. The appearance of widgets for desktop GUIs remains consistent across different types of applications and it relies on office-related metaphors and visual cues, in order to suggest affordances for mouse and keyboard interaction (e.g. 3D effects for clicking buttons, white fields for text entry, ripples on the moving part of scrollbars for dragging). When information is displayed for a different interaction style, and enters different domains of mixed reality, new affordances need to be designed for users' understanding of the interaction conceptual model (see fig. 1). More natural ways of manipulating information need to be thought through; thus, we need visualization and interaction techniques which effectively support users' interaction among each-other and with the system.

Surfaces as interfaces, hands as controls

My research focuses on an interaction paradigm which avoids the use of mouse and keyboard, aiming at direct manipulation of units of information across different displays and contexts. In such a paradigm, surfaces act as interfaces, and hands as control devices. While the mouse has a limited manipulation vocabulary (e.g. click, double click, click and drag, right click) hands, fingers and gestures provide a much more varied one (e.g. press, draw a circle, point, rotate, grasp, wipe, etc.). Rekimoto [2], Ringel [3], Butler et al. [1] exploit such variety working on two-hands, multiple fingers gestures vocabulary. In most of this work the user needs to rely on the memory of a set of actions to be performed, in order to operate with the system: the memory of such a set of actions is not supported by an explicit mapping between perception and action, which is the essence of affordances.

My intent is to design affordances for the representation of digital information which can suggest the hand gestures to be performed by the user. In the following I present some examples in which I apply this concept.

The Mug Metaphor Interface

While the desktop metaphor suits the type of environment in which the computing capabilities have been mostly applied so far (i.e., the office), it runs short in other scenarios of ubiquitous computing. In the Mug Metaphor Interface [4] I investigate the possibility to map the affordances of real world objects to gestures, relying on the manipulation vocabulary and on the conceptual model of such physical objects.

When manipulating a real mug, for example, we know we can move it around by holding its handle, and incline it to pour its content (see fig. 2, top). Empty mugs are expected to be lighter than full ones (e.g. contain less data), smoking mugs are expected to be hot (e.g. contain recent data). Additionally, a mug is an everyday life object which we use in different environments, e.g. in the office, in the living room, in the kitchen. In the Mug Metaphor Interface digital mugs and units of information, the latter represented as kind of drops, can be manipulated across the display. Pie menus appear in correspondence of the hands, thus "following" the user while moving across the display, rather than being operable just in a fixed location on the screen. This responds to the need of freedom of movement of the user, and to enable two-hands cooperative interaction (see fig. 2, bottom).

Figure 3: The Living Cookbook interface: the dial embodies the cookbook selection; video control is operated on an egg-shaped widget (second from top); portions can be specified by dragging plates on a table (bottom).

The Living Cookbook

In the Living Cookbook project I explore the introduction of digital display technology into the kitchen environment and the cooking activity, meant as social experience. The idea behind the design of such a domestic appliance is to exploit available technology in order to enhance people communication, creativity and collaboration around the cooking activity [5]. The appliance consists of a camera, a tablet PC with touch sensitive display mounted on a kitchen cupboard and a projector connected to a server (see fig.3, top). On the tablet PC a multimedia digital cookbook is displayed and controllable (see fig.3, middle and bottom). On the same interface people can either author a new recipe in their personal book, or consult the book and learn someone else's recipe. In the authoring/teaching mode, the video of the cooking session is captured by the camera: in the learning mode the video is projected on the wall above the counter and the learner can cook along.

To create the link to domestic activities, the metaphor of a traditional cookbook is used. The book metaphorically offers the affordances of paper, where people can both write and read, and flip pages: this comes at hand to display both the authoring and rendering environment using a consistent conceptual model. Furthermore, the emotional aspect of authoring a book is supported: users can go back to their personal cookbook, see the recipes they authored, thus enhancing a sense of "paternity" and memory. In the dial people can choose among a set of cooks/buddies, and among courses. This combined selection triggers the cover of the book displaying the picture of the selected cook, and of the desired course. Pages can be flipped by touching a flipping corner, which is smoothly animated to make the user aware that content is provided in the next pages. Wherever possible, affordances for direct manipulation are provided, such as tapping and dragging, in order to minimize text input. In our widget-based design different widgets are metaphorically referring to artifacts of a normal kitchen and semantically related to different functions (see fig3, middle and bottom).

The EnLighTable

The EnLighTable is an appliance based on a table-top touch-sensitive display for creative teamwork in the selection of pictures and layout design, e.g. in advertising agencies. It enables multiple users to simultaneously manipulate digital pictures of a shared collection, and rapidly create and edit simple page layouts. The hybrid nature of the appliance, together with its social context of use, imply to consider the existing physical, as well as social affordances provided by the table as a physical artifact. Additionally, cognitive affordances for the manipulation of digital information as well social affordances for collaboration need to be designed.

When users sit at the sides of a table in the physical space, personal areas of interaction are implicitly determined by people's area of reach and visual angle. In analogy to plates on a set table, we suggest personal areas of interactions by arranging three *Imagetools* in a predefined position, oriented towards the sides of the table. *Imagetools* are movable virtual tools for basic editing of digital pictures (see fig. 4). In the center, a bigger shared container of information is displayed, which contains the thumbnails of a shared picture collection. The tray can be dragged towards the personal area of interaction. When such a "shared tray" is dragged in the direction of one of the *Imagetools*, the pictures reorient towards the dragging user, so that she

Figure 4: From the top: a user drags slides out of the shared tray; in the middle, the user positions selected pictures under the *Imagetool* virtual lens; at the bottom, affordances for two-hands interaction. The image can be zoomed by scrolling the left gear; and cropped by dragging the semi-opaque ledgers within the lens, which resemble the blades of a four bladed photographic easel.

can drag the preferred ones out of it: i.e., she can "serve" herself with the desired information items (see fig. 4, top). After the user ceases interacting with the shared tray, the latter automatically returns to the original orientation and location. In this way, a consistent spatial arrangement of the pictures is mostly maintained, thus supporting spatial memory for every user. In analogy to design and photographic working scenarios, where slides are often arranged on light tables in order to simultaneously visualize and compare multiple pictures, our information items visually resemble slides (see fig. 4, middle). Copies of the original slides in the shared collection can be edited with the *Imagetool.* This adopts the conceptual model of a magic lens, which in our case is controlled by two hands directly on the surface of the table. Such virtual tool provides cognitive affordances for direct manipulation relying on the way we manipulate certain physical objects (see fig. 4, bottom). The zooming gear on the left side of the tool, for example, can be "scrolled" with a continuous movement of one hand. Discrete interaction, such as tapping, is suggested by the 3D effect of the buttons for mirroring and saving changes, on the right side of the tool.

A New Design Perspective

The design of affordances for digital information embedded in a real physical environment and social context implies the consideration of new aspects which differ from the desktop PC environment. The users' possibility to move around in the space and to directly manipulate objects and information items needs to be supported by interfaces that are properly scaled to users' metrics, locations in the space, reciprocal distance among users and motor capabilities. Issues such as the height of the user, her visual angle, the reachability of displayed objects to the hands, the proportion between objects and hands sizes, assume an important role. In order to face such issues, ergonomic considerations need to be included in the interface design, thus suggesting the emergence of a novel design approach. The traditional usability guidelines for visual displays will most likely need to be revised in order to address the novel aspects brought by ubiquitous computing. In these scenarios I expect that the design discipline will need to merge screen and product design competences, in order to merge virtual and physical worlds.

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