Parsimony & Transparency in Ubiquitous Interface Design

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ABSTRACT

Minimalism in ubiquitous interface design allows computational augmentations to seamlessly coexist with existing artifacts and the constellations of task behaviors surrounding them. Specifically, parsimony and transparency contribute to improved learnability and user acceptance of novel interfaces.

Keywords

parsimony, transparency, minimalism, design, tangible, ubiquitous computing, learnability

DESIGN OVERVIEW

We present a design philosophy for ubiquitous computing centered on parsimony and transparency. By transparently integrating aspects of the digital world into real artifacts, we strive to provide ubiquitous interfaces to computation that do not obscure or destroy the highly refined interaction modalities of the host artifact in the physical world. We believe that carefully crafted coexistence of the physical and the digital, based on minimalism, leads to more learnable interfaces.

We also present a system that demonstrates this design philosophy: an augmented go board. The game of go is a demanding test case because it is surrounded by a set of behaviors and aesthetic concerns that have been refined over the course of thousands of years. Our system provides a flexible, modeless augmentation of go by adhering to minimalism.

Minimalism doesn't necessarily imply limited functionality. Transparent design means minimizing cognitive demands on the user by limiting the changes to the pre-existing constellation of behaviors surrounding the artifact being augmented. For example, the augmented go system transparently adds game recording and an automatic move clock to traditional face-to-face play with no change to the traditional experience.

Furthermore, parsimony means minimizing the introduction of interface elements and inappropriate metaphors that could lead to clutter. The traditional activities of solitary review, study, and problem solving are enhanced by the addition of minimal visual augmentations that are appropriate to the game context and therefore preserve the game aesthetics. The traditional experience is actually improved because the user is free not only from distractions in the interface, but also from the usual distractions of notes, reference books, and newspapers.

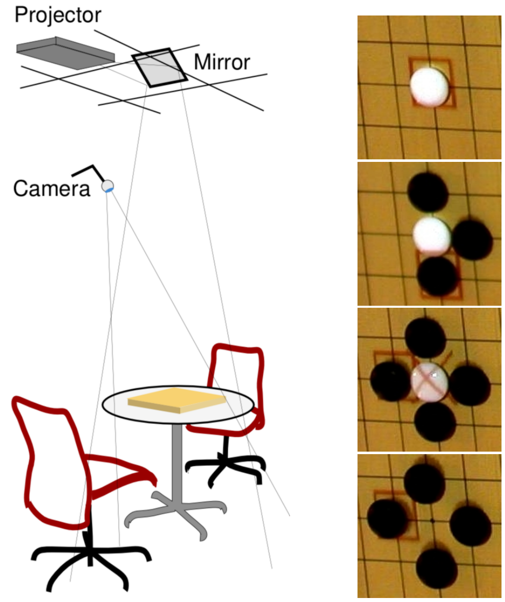

Figure 1: Left: The system. Right: A sequence of moves shows the visual annotation. The red box indicates the last move. The red $\times$ indicates a white stone that should be removed.

An overview of the physical configuration of the system, as implemented, is shown on the left side of Figure 1. The right side of Figure 1 shows examples of the projected patterns used to augment the board.

IMPLEMENTATION

The system we implemented is governed by the design philosophies of parsimony and transparency articulated above. The system itself consists of a light-table comprised of a video camera and projector situated above a go board on normal table. The system projects visual annotations that form a superset of the traditional board functionality: a game clock, a remote or artificial opponent's moves, and a minimal interface for exploring game variations. The vision system explicitly supports our design philosophy by accommodating the traditional style of game play. Unlike some other tangible user interface (TUI) light tables, like Underkoffer and Ishii's URP[3], our system relies solely on unmodified, traditional artifacts. Moreover the system is adaptive to various lighting and geometrical arrangements of the go board. What this means is that users interact with the light table-enhanced go board as they traditionally would, but are also provided useful augmentations. Consequently, players already familiar with go can learn to use the interface quickly because we've minimized the behavioral adjustments needed to use our interface.

EXPERIMENTAL VALIDATION

We verified our assertions about learnability by conducting a user study that we will briefly detail here. The experiment had two conditions: a well designed graphical user interface (GUI), and our augmented physical board. The experiment compared these conditions within subject (over 10 subjects). The independent variable was the choice of condition. The dependent variable was time on task. The task for both conditions was to play out a game and explore a variation of that game. The ordering of which condition subjects first encountered was randomized. We infer that our system is more learnable because the time on task for users with no experience with the game was less with our system, than with the GUI. Given the null hypothesis that the mean times are the same for the two conditions, but with unequal variances, the two-tailed probability that this data represents the null hypothesis is $\boldsymbol{p} = 3.3817 \times 10^{-6}$. Our system was also subjectively reported by subjects as preferable.

Table 1 shows the data from the experiment. The prefix on the subject number indicates which condition was experienced first: 0 for TUI, 1 for GUI. The † denotes that the participant failed to complete the task before the time limit (n.b. this only happened in the GUI condition), and μ and σ give the mean and 95% confidence interval for the data. Questions 1 and 2 asked the subject the difficulty of using our system and the GUI, respectively (with 1 indicating easy). Question 4 asked the subjects their preferred system (with 1 indicating a preference for our system). Answers were given on a five point scale. The remaining questions established the subjects' familiarity with go and with computers in general. Our thesis is that transparent, parsimonious TUIs are more learnable, and we have shown this to be true in a limited domain of comparison (with respect to a representative GUI).

Sub	TUI	GUI		Q1	Q2	Q4
0-1	4.58	7.97				
0-2	7.62	10.13		1	2	1
0-4	5.27	8.65		1	1	5
0-6	4.20	11.45	†	3	5	1
0-7	4.77	10.08		2	3	2
1-0	3.78	11.45	†	1	4	1
1-1	4.35	5.83		1	3	2
1-2	4.93	11.45	†			
1-5	4.28	11.45	†	1	3	2
1-6	4.28	11.45	†	1	4	1
μ	4.81	9.99		1.38	3.13	1.88
$\sigma\pm$	0.34	0.61		0.25	0.41	0.45

Table 1: Time on task data (in minutes) and select answers from the questionnaire.

RELATED WORK

One aspect of this work is the constructive coexistence of the physical and the virtual. In this respect this work is similar to the work of Wellner on the DigitalDesk[4] and is informed by Ishii's pioneering efforts in tangible user interfaces[3, 2].

Another aspect of this work is the desire for transparency and minimal cognitive demands on the user. In this respect it is inspired by work on sympathetic interfaces[1] and supported by the prior literature on perceptual interfaces[5].

CONTRIBUTIONS

This work focuses on a design principle for augmenting the traditional, physical tasks that consume a large part of everyday life. This is in contrast with much of the tangible interface literature that focuses instead on the useful, but different task of giving graspable manifestation to digital information [2].

This focus on existing artifacts demands tranparency and parsimony. Transparency seeks to minimize the impact on the constellation of existing human behavior that surrounds the host artifact. Parsimony supports transparency by minimizing the clutter that distracts attention, and avoiding inappropriate metaphors that add cognitive load. Parsimony is also important for preserving the aethetics of the host artifact. This minimization, avoidance of complexity, and preservations of traditional aesthetics all contribute to the increased learnability of our interface.

The go board is a particularly challenging artifact because of its highly refined aesthetic and behavioral constellation. We have presented an augmented go board that sucessfully showcases a minimalist ubiquitous computing design approach based on parsimony and transparency.

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