

Poster Abstract: Developing Standards for Affordances on Embedded Devices

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ABSTRACT

Embedded devices are ubiquitous in our environment, including computing systems as widely diverse as digital watches, automobile dashboards, factory controllers, thermostats and other appliances. Traditionally, little attention has been paid to the user interface in such low-cost, dedicated-function devices. However, new technologies such as touchscreens are changing the landscape of embedded user interface design. Additionally, recent research has demonstrated that usability can have a significant effect on embedded device efficiency. Research on programmable thermostats in particular points to the need for proficient and consistent user interface design in order to realize energy savings nationwide. We discuss preliminary results from an in-depth usability study conducted on five programmable thermostat interfaces (three touchscreen, one web, and one-button based) with 31 participants. Our research suggests that users lacked a consistent mental model of how to interact with buttons, text, icons, and other features of the device. We hypothesize that discrepancies between perceived and actual affordances on the device had a measurable impact on users' ability to successfully accomplish key tasks on the thermostats.

Categories and Subject Descriptors

H.5.2 [Information Interfaces & Presentation]: User Interfaces – *input devices and strategies, interaction styles, standardization, user-centered design.*

General Terms

Design, Human Factors, Standardization.

Keywords

Embedded devices, touchscreens, thermostats, appliances, interface standards, affordances, usability.

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1. INTRODUCTION

We interact with embedded systems everywhere in our daily lives, from digital watches to automobile dashboards to household appliances, yet there has been significantly less user interface research conducted on these low-cost, dedicated-function devices than on the desktop. However, at the same time that general-purpose computing devices are becoming smaller and more portable, embedded devices are becoming more powerful and incorporating new technologies such as touchscreens. With the increased power of embedded devices, such systems are impacting ever larger aspects of our daily lives. This has implications that extend far beyond the traditionally local scope of embedded systems. In particular, household appliances and thermostats have been shown to have a significant effect on energy use nationwide. Recent studies estimate that US residential thermostats control 11% of the nation's energy use [3]. However, usability issues with modern programmable thermostat design are leading to errors in operation and wasted energy.

We conducted a usability study on five commercially-available residential programmable thermostat interfaces (three touchscreen, one web, and one button-based) to evaluate device affordances and effectiveness. Our goal was to determine if correlations could be found between the size of the discrepancy between perceived and actual affordances and the users' effectiveness at performing common thermostat tasks such as setting heating temperatures and programming weekly schedules.

We found that several of the programmable thermostat interfaces were complicated and difficult for users to understand, leading to frustrations and significant barriers to completing the tasks. This poster discusses preliminary results and possible solutions, including consistent design standards tailored to embedded devices that can help overcome these interaction barriers.

2. METHODOLOGY

We conducted a thermostat usability study with 31 participants, nine female and twenty-two male, ranging in age from 18 to 65. The experimental design included both between-subjects and within-subjects variables. Each participant performed the same six tasks on each of two out of five thermostat interfaces. The

interface order was randomized to account for learning. Subjects were recruited via online classifieds and were compensated for their time.

2.1 Tasks Performed

Tasks were designed to reflect key functionalities of the thermostat. They included setting the thermostat to heat mode, setting the day and time, identifying the current temperature, identifying the temperature setting of a future period, putting the thermostat in hold or vacation mode, and setting a program schedule. All testing sessions were video recorded for future review and data collection purposes.

2.2 Experimental Design

Data was collected for each task, including task completions, times, function paths (buttons and function interactions), interaction motion (press, slide, hold, etc.), interaction errors, and experimenter observations regarding users' confusion. Interaction errors were recorded as actions with no effect, or A_{ne} , defined as any action that did not change the state of the thermostat. A_{ne} actions included failed attempts at opening the device's cover or flap, touching text or icons that were not touch sensitive, pressing buttons or functions that did not change the device's state within the current mode, and performing any motion on the device that did not change the state [Table 1].

Table 1. Example of recorded functions and user interactions.

Function	Motion	Number of Actions with No Effect A_{ne}
Clock	Press	0
Up Arrow	Hold	0
Schedule Screen	Slide Left	1
Schedule Screen	Slide Right	1

3. EVALUATION

We wanted to explore whether A_{ne} would provide a way to measure discrepancies between perceived and actual affordances on the interface. An initial evaluation of the sum of A_{ne} did not demonstrate any correlation between the sum of A_{ne} and the completion rate; however, we are currently in the process of evaluating other possible metrics and relationships to determine whether summing A_{ne} was an appropriate measure of affordance errors.

3.1 False Affordances

Many users attempted to perform actions on perceived affordances when these actions were not actually possible on the interface. These types of affordances, often called false affordances in the literature [2, 6], suggest a mismatch between users' perception and the allowable actions on the interface itself. Common false affordances occurred on the touchscreen interfaces when users pressed text or icons that were simply not touch sensitive [Figure 1]. Other false affordances included indentations on the outside of the device that did not actually

indicate a cover or flap that could be opened. While web interfaces often use "hot spots," windows or scroll bars to indicate common perceived affordances [1], there appeared to be no consistent approach for programmable thermostats.



Figure 1. An example of a false affordance of text.

3.2 Perceived Interaction Motions

Our research suggested that there were many types of physical motions that were perceived as affordances by users that were not actionable on the device. Examples of failed interaction motions include users sliding across an area of the interface that required pressing, or tapping on an area where holding down was a more effective motion. These interactions gave some insight into users' mental models regarding what type of motion should be performed. There has been interesting research on how humans cognitively process these types of motions [4] and we would like to further explore how a standardized design feature could indicate the appropriate motion a user should take.

4. DISCUSSION OF STANDARDIZATION

A standardized approach to interface design and affordances for thermostats and other embedded devices could allow for a more consistent mental model among users. Nielsen, in evaluating a touchscreen device, observed the need to "add dimensionality and better define individual interactive areas" as well as "support standard navigation" for users [5]. While standards specifying dimensionality and interaction areas could very well be effective for touchscreens on embedded devices, our preliminary research shows that much work is yet to be done on how motions and other affordances might be applied.

5. ACKNOWLEDGMENTS

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