Integrating Semantic Mapping with Rich Interaction in a Music Player

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Abstract
Semantic meaning can be integrated into tangible interfaces through integration of metaphorical mapping with the Rich interaction framework. This mapping can complement the information-for-use proposed in the Rich Interaction framework. A prototype was designed with integrations of these different mappings. A future study will have the expected outcome of better understanding the limitations this design approach and testing usability to see if users prefer this method of interactive product design.

Author Keywords
Tangible user interface; metaphor; semantics; Industrial Design

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): User Interfaces: Theory and Methods

Introduction
This study concerns the gap between the *semantic* approach and the *direct* approach to designing tangible interactive products. The area of study is situated between tangible interaction, new interface forms, and functional mappings. I am aiming to analyze the potential benefits of synthesizing semantic meaning into the tangible form of an interactive product, in

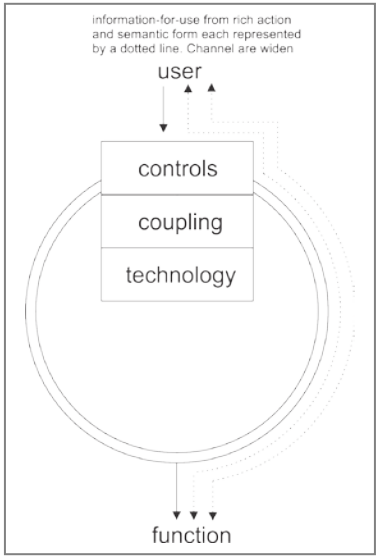

Figure 1. Propose new model build on original rich action frame work [2] where semantic form is added additional the original framework represented by the outer dotted line.

order to complement the carried meaning of physical form during. Through this approach, I aim to gain an understanding of the mechanics by which value from the semantic approach may be added to Joep Frens' rich interaction framework [2].

Currently, the rich interaction framework only considers the mechanics of the direct approach, and the benefits of interaction rooted in human perceptuo-motor skills, with the goal of reducing the abstraction of available information-for-use [2]. However, literature regarding semantics [3] and metaphorical mappings for tangible interaction design [5] suggests that there is potential to leverage semantic ways of knowing to minimize the abstraction of information-for-use in interactive systems. I suggest that if the semantic approach can provide this reduction in abstraction, then it is a relevant approach that adds value to the rich interaction framework.

Background

In Frens' thesis on the rich interaction framework [2], as well as an earlier study regarding the nature of appearance and action in tangibles [1], the semantic approach and direct approach to designing interactive products were contrasted. Semantics, in this context, is an area of design in which meaning is created through symbolic signs [3], which indicates a focus on conceptual ways of knowing. By repeatedly using one's perceptuo-motor and sensorimotor skills in everyday life from an early age, we gain semantic knowledge by recognizing patterns from common ways of acting in the world, and expectations of what the result will be.

The direct approach also originates from experience using one's perceptuo-motor and sensorimotor skills in everyday life, however, rather than conceptual ways of knowing and cognitive processing, this Gibsonian-inspired approach focuses on designing towards immediate information on the action-possibilities of one's present environment, and prompting interaction in response, to create meaning [1, 2]. In short, in the semantic approach, perception leads to action, while in the direct approach, action leads to perception.

In order for this approach to work, Frens [2] created a framework that explores form, interaction and function simultaneously. The result is functionality represented in form, and providing information-for-use in interaction, rather than a coupling layer (for which thinking and interpretation are required due to the abstraction in the relationship between form and function).

Information-for-use plays an important part in this framework, and how semantics may add to it; it is defined as more or less abstract information that a user perceives in order to understand how to use a product [2]. When functionality provides information for use, in line with perceptuo-motor skills and action-possibilities, the channel for information-for-use is broadened, and abstraction is minimized, two requirements for greater usability in interactive products.

However, the semantic approach can also provide information-for-use: if semantic knowledge could be integrated into the form of the product, it would keep functionality as the source of information-for-use, and add to rich interaction. In the direct approach, form is not arbitrary: it communicates possible actions, but does so because the user understands what possible actions can be performed with the form [1, 2].

Figure 2. Semantic interactive prototype on the left, function is activated by tilting or metal ball. Conventional prototype with buttons on the right.

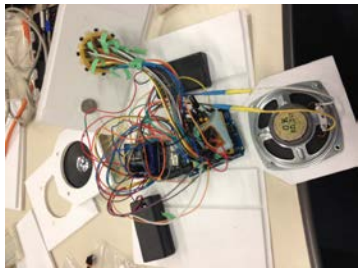

Figure 3. Electronic components in the interactive prototype.

Within the scope of semantics, I use image schema and its metaphoric extensions as a lens, as this concept is "rooted within the meaning of objects in the world rather than mechanical features." [4] Image schema are patterns of sensorimotor experiences that structure our understanding of the world, and metaphorical extensions define one kind of thing in terms of another, also to structure understanding of something abstract. This is the starting point to create mappings that integrate with a form that employs rich actions.

Macaranas [5] clarified strategies for intuitive mapping for interaction design that are applicable to this context. The strategies are: metaphoric mapping, isomorphic mapping and conventional mapping. There are limitations to each type of mapping: isomorphic mapping cannot be applied unless there is a 1-to-1 context for the spatial relationship. For conventional mapping, the user may not know the convention or there may be multiple conventions, thus introducing unforeseen abstraction. Lastly, metaphoric mapping may break down, removing information-for-use and increasing abstraction, because the object no longer reflects the real-world concept behind the metaphor.

Despite these limitations, it is clear that these semantic mappings are useful for providing additional information-for-use. Considering how the direct approach limits abstraction, I propose that integrating semantic mappings with the form of the product may draw information-for-use from functionality as well, and limit the scope of the metaphors to a single, clear function Figure 1. The research question for this study is to explore metaphoric mappings in tangible form utilizing the approach inspired by rich interaction, and to evaluate the perceived ease of use and usability of the prototypes. Perceived ease-of-use is explored because measuring if the product effectively invites action is a crucial part of the rich interaction framework [2].

In the next section, I outline my requirements for a prototype mp3 music player, and the research-through-design process that led to its development.

Design

The purpose of building the prototypes is to conceptually explore synthesizing the semantic and direct approaches to building tangible interactive products Figure 2: for this, I constructed two prototype music players. Both prototypes have a basic set of music player functions: Play/Pause, Stop, Volume and Skip Track (Forward/Backward). The first prototype acts as a baseline to compare against, therefore it is a conventional music player comprised of labeled buttons, symbols and dials. The second prototype was constructed to explore the feasibility of integrating semantic knowledge with the direct approach in the form of our prototype. To achieve an integration of semantic meaning with rich actions, the mapping must be represented in a manipulable tangible form.

Characteristics of this prototype consist of both metaphoric mappings and conventional mappings integrated with the physical form. Figure 5, The metaphoric mapping used is one of an IN-OUT image schema, and is tied to the Play, Pause and Stop functions of the prototype. By placing a metal marble within the grooves, the proper functions will be triggered. Conventional mapping is used to define the function of skipping tracks Figure 4: tilting left or tilting right is a conventional analogy of moving backward or

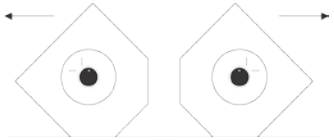

Figure 4. Conventional mapping: tilting left and right for skipping track forward or backward.

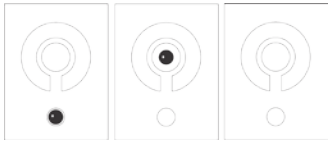

Figure 5. Metaphoric Mapping: In and out schema. Black dot is the indicator for metal ball. Left: stop Middle: Play Right: pause

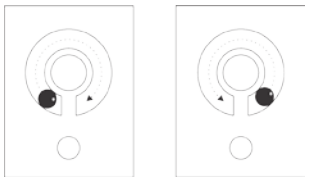

Figure 6. Conventional and metaphoric mapping: Volume control. Metal ball can be place inside the groove to change volume, location of the ball is a indicator for scale of the volume.

forward through a list of items, including tracks in a typical music player.

For the volume control Figure 6, there is a combination of mapping approaches: since the volume is increased through clockwise motion, this demonstrates a conventional mapping, while having the control situated within a container and manipulated with a physical object employs a metaphorical mapping as well, since the activation of the control is dependent on the object being IN or OUT of the container. The magnetic marble in our prototype is a means of controlling the functions.

There is also a materiality consideration, since different material qualities will create different expectations for the prototypes. The material elements hence need to be consistent to the dependent variables between prototypes. As a result, all prototypes were constructed out of white foam core, to maintain neutrality.

Finally, the circuit for the prototype with integrated mapping is comprised of an Arduino, mp3 shield, amplification breakout, speakers, hall effect sensors, tilt sensor and speakers Figure 3. The sensors include tilt sensors and unipolar Hall Effect sensors. The main function of the tilt sensor is responsible for detecting the left or right tilting of the prototype. The Hall Effect sensor is responsible for detection of the metal marble.

Discussion

The integration of semantic meaning into the form of a product was successful in our prototype designs, as there are several metaphoric and conventional mappings represented in the form itself and through its functionality. To properly express the value of this design process, however, evaluation is needed. I take inspiration from the evaluation process of Frens' camera prototypes [2], in which the more practical measures of the values of his approach were of perceived ease of use and conventional usability (through efficiency and effectivity of completing tasks), to evaluate the prototypes in this study.

Conclusion

This study investigates the potential for semantic knowledge to be integrated into the physical form of an interactive product. Two prototype mp3 music players were created for the purpose of evaluation from our research question. Future work will explore creating a third prototype employing purely rich interactions, to compare between this approach and our hybrid approach.

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