Three Strategies for Designing Intuitive Natural User Interfaces

Anna Macaranas, Alissa N. Antle, Bernhard E. Riecke
School of Interactive Arts and Technology - Simon Fraser University
250 – 13450 102 Avenue Surrey BC Canada
[amacaran; aantle; ber1]@sfu.ca

ABSTRACT

We present three strategies for designing mappings between body-based input actions and controls for Natural User Interfaces (NUIs). Designers may design mappings unaware of the benefits and limitations of each strategy. Furthermore, each approach may result in intuitive interaction – fast, automatic, and unconscious interaction based on prior knowledge. In this paper we describe three strategies for designing input-control mappings, provide a brief introduction of intuitive interaction, and suggest how and why each of these strategies may facilitate a form of intuitive interaction. With this knowledge, designers can explore how each strategy supports intuitive interaction within the context of their design problem.

Author Keywords

Intuitive interaction, natural user interfaces.

ACM Classification Keywords

H5.2. Information interfaces and presentation (e.g., HCI): Interaction Styles, Theory and Methods.

General Terms

Design, Human Factors.

INTRODUCTION

Natural User Interfaces (NUIs) are a category of interfaces that use body input actions (i.e. hand gestures, arm motions, whole-body movement) for system controls. NUI controls can be designed following established conventions from analog or physical controllers or by leveraging existing knowledge from our everyday gestures in the world. For example, home stereo systems use a convention of turning a physical dial clockwise to increases the volume of music. This convention can be applied to a NUI so that a clockwise rotation of a finger or arm increases the volume of the system. Likewise, raising an arm or a device can increase volume – actions similar to a conductor raising her arms to encourage an orchestra to play more loudly. Should a NUI volume control involve a rotation or an upward motion? We see this type of question as a common problem in the design of new interface forms. Norman states that NUIs are not natural by default and careful design is needed to create clear and intuitive mappings [7]. Our work contributes to the development of NUI control design by offering these different strategies for discussion amongst designers. They can compare these strategies to their own as well as explore how these specific strategies affect their designs.

DIS 2012, June 11-15, 2012, Newcastle, UK.

INTUITIVE INTERACTION

Intuition in Cognitive Science

Bastick describes intuition as a cognitive process that uses information previously perceived by the senses [3]. This sensory information is used to make insights, recognitions and judgments [3]. Likewise, Lakoff and Johnson introduced *Conceptual Metaphor Theory* (CMT) to explain how we implicitly reason about the world [6]. CMT states that people make sense of abstract concepts by using mental structures formed from recurring sensory-motor experiences [6]. CMT provides a mechanism that can account for some of what Bastick defines as intuition. Both theories suggest that we unconsciously use cognitive structures formed from repeated sensory-motor experiences to make sense of new experiences or situations. When one applies such structures successfully, he "intuitively" understands something. Such understanding requires no learning and little conscious attention, enabling one to focus her attentional resources on another aspect of the activity.

Intuition in Human Computer Interaction

Blackler et al. described intuitive use as being based on our experience with previous systems [4]. In this paper, we call mappings where users use knowledge from previous systems "conventional mappings". Designing controls based on conventional mappings presents some issues. What if more than one convention exists? Are conventions always the most usable in a NUI context? What are other strategies for designing NUI controls?

Several researchers have explored how CMT can be used to create mappings that are intuitive because they are based on repeated patterns of everyday actions and interaction [1,2,5,8]. Findings from their studies suggest that designers can create effective and efficient mappings by using prior knowledge based on sensory-motor experiences. Users can apply knowledge gained from everyday patterns and relationships with space, movement, and physical properties towards understanding and effectively using these mappings. It provides designers with a systemic way to inform their designs rather than uncritically relying on conventions from physical, analog or digital systems.

STRATEGIES FOR MAPPING INPUT TO CONTROL

We describe three different strategies for mapping body input actions and controls for a NUI. Image schema-based conceptual metaphor or *metaphoric mappings* are those that structure input actions based on image schemas – mental models formed from repeated patterns in everyday experiences – and system effects based on related conceptual metaphors. We can explain this through an example. A primary image schema all humans develop early in life is UP-DOWN. This image schema forms the basis for many metaphorical interpretations. A simple example is the metaphorical association of UP-DOWN with quantity. "Up" is associated with "more" and "down" with "less". When we fill a cup or add objects to a pile, we notice the substance or object grow in height. The metaphor UP IS MORE is a cognitive structure based on these everyday experiences and used – unconsciously – to understand a variety of more abstract concepts. For example, we use this metaphor to make sense of system controls (e.g. raising the sound volume by moving the slider up). Because this understanding is processed below the level of conscious awareness, we call it "intuitive" and interaction based on it, "intuitive interaction".

Isomorphic mappings are one-to-one literal spatial relations between the input actions and resulting system effects. The most common form of isomorphic mappings is physical-physical. An example is a racing game for a whole body system where the player's movement is mapped to a car's movements. Players turn their body left to turn the car left. However, these physical-physical mappings may not be possible in more complex systems. Another form of an isomorphic mapping is physical-abstract. For example, one could map the physical amplitude of a sound wave (i.e. volume) to an abstract array of hollow ticks. Each tick represents a constant amount of amplitude and increasing the system's sound volume involves filling in a tick. The amplitude of the system's sound is mapped to the area of ticks filled in. For both examples, the input and system response have the same – isomorphic – structure. Isomorphic mappings can be intuitive if the user understands the nature of the structure being controlled by the interaction. For example, the array of ticks may not be intuitive for a user who does not think of volume as a parametric value that could be increased at a constant rate.

We define *conventional mappings* as those adapted from previous practice and commonly found in product interfaces. In order to differentiate conventional from metaphoric and isomorphic mappings, we limit them to those found in other systems but NOT grounded on image schema-based metaphors or one-to-one mappings. Since they are conventions in many products, they are familiar to many users – however in most cases, their origins or structuring may be random. An example of such an established mapping is the arrangement of letters on a QWERTY keyboard. Typically, conventional mappings have to be learned and take time to become established in design practice. An example of a conventional mapping for sound control is the previously mentioned physical dial that increased volume with a clockwise rotation. Associating clockwise movements with increased quantities comes from our experience with clocks, radio dials, screws and jars – clockwise rotation increases time, numeric values and tension. Conventional mappings can be intuitive since they are based on our experience with previous systems. However as stated previously, the structures of these mappings may be arbitrary. Currently, very few conventional mappings exist for NUIs.

ONGOING WORK

Based on our classification of these three strategies for designing mappings between body input actions and NUI controls, we are now implementing a comparative study to investigate the benefits and limitations of each in supporting intuitive interaction with a whole body system.

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