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From action icon to knowledge icon: Objective-oriented icon taxonomy in computer science

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ABSTRACT

Icon plays a critical role in computer interface design. Studies on icon taxonomy explain the way in which various types of icon represent the objects and provide designers creation rules by which icons are more in line with users' cognitive psychology. However, along with larger and larger use of icons, the previous classification criterion causes the boundary between categories blur. What's more, Single classification standard is not able to well illustrate the icons applied in today's computer applications. The purpose of this paper is to present an objective-oriented icon taxonomy which proposes to categorize icons into action icon and knowledge icon. To assess this proposition, we analyzed a sample of icons that applied in computer interface and suggest precise application domains to both action icon and knowledge icon categories. The results of this practice manifested that action icon and knowledge icon implied a high relation with applied environment and explicated the development trace of computer icons. This work is one of the first to point out the notion of knowledge icon and to highlight the importance of objective of icon application. Findings in this paper could enrich icon use in computer interface design, especially provides possible way to improve online knowledge sharing by visual tool like icon.

1. Introduction

The principle of iconic representation may be partly demonstrated from the evidence of imaged cognition [1]. "People often recognize pictures of things and understand them more quickly than they do verbal representations of the same things." [2] Early research in Dual-coding theory [3] postulated that both visual and verbal codes for representing information are used to organize incoming information into knowledge that can be acted upon, stored, and retrieved for subsequent use. The theory showed that memorization for some verbal information is enhanced if a relevant visual is also presented or if the learner can imagine a visual image to go with the verbal information. Likewise visual information can often be enhanced when paired with relevant verbal information.

Several definitions offered by experts tried to make clear boundaries between the terms of icon and symbol [4,5]. For example, Horton considers icons as a subset of symbols [6]. McDougall argues for an inverse subordination between these two concepts: "For the sake of simplicity, icon is the term used [...] to refer to the broad range of icons, signs, or symbols used to help individuals interact with machines and their environment" [7]. Marcus argues for a distinction between an icon and a symbol in terms of the concreteness of the representation: "Icons are signs that are familiar, are easy to understand, and are often concrete representations of objects or people. Symbols are signs that are often more abstract and require specific instruction to learn" [8].

In this paper, we follow Horton's definition of icons to consider "icon" is a general reference of visual symbol. Particularly, we define that the symbolic characters of icon imply how an icon signifies the object while the graphical characters referring to the graphical variable used in an icon, like color and shape.

Computer icon (henceforth "icon") plays a critical role in Graphical User Interface (GUI) [9]. It is a group of icons displayed on the computer screen in conjunction with computer windows, menus and a pointing device form of computer system and enables the user to easily and intuitively navigate the system. One of the most notable icon designers, Susan Kare was quoted saying "good icons should be more like road signs than illustrations, easily comprehensible, and not cluttered with extraneous detail" [10].

Studies on icon taxonomy provided deeper theoretical explanation of iconic representation from the view of its characteristic. They illustrated what kind of icon existed and how each kind of icon signified the target through symbolic characters and graphical characters. The findings in turn served later icon design and

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implied why some icons were better accepted than others. However the previous studies focused more on physical appearance of icons themselves instead of considering the influence on applied environment. Moreover, the former findings were carried out based on simpler computer background where user's perception was single and icon needs was direct. Following the diversity of users and icon applications, the static icon-character-oriented taxonomy could not satisfy completely icon research. Besides, the development of visualization and knowledge engineering creates more changes for icons. They are employed not only for user's operation guide but also in use of knowledge representation, in order to enhance knowledge understanding and knowledge reuse under sharing environment. This is one of the reasons to form two icon sets which have a strong relationship with icon applying trends: action-oriented and knowledge-oriented.

Consequently, we are proposing an objective-oriented icon taxonomy, which highlights the use purpose of computer icons rather than their graphical characters or symbolic characters. This applied-domain-focused icon taxonomy is supposed to improve computer icon serving for information visualization. On one hand, new categorizing criterion will enrich icon taxonomy study. How one icon could represent an object is not the only analysis point of computer icon any more. Where this icon is able to be applied and why it occurs on this kind of interface design is also interesting to be emphasized. On the other hand, deeper illustration on icons that are suitable in each applied field will enhance the understanding on the potential of icon and in turn explore more possible icon-based interface design. The icon design could start from applying needs instead of seeking appropriate platform for the icons that have been created. This study is assumed to be meaningful for icon-based human computer interface both at theoretical level and practical level.

This paper will firstly review the development path of icon taxonomy, respectively from physical appearance, user perception and representation strategy, these three main criterions. In Section 3, we will explain the proposed icon taxonomy and present two icon categories produced by it: action icon and knowledge icon. Then in the next section, a test carried out to demonstrate new icon categorizing criterion will be presented and typical application domains of each icon category will be precisely illustrated. Discussion on this objective-oriented icon taxonomy will be also analyzed in details. Finally, we conclude.

2. Background – previous studies on the taxonomy of computer icons

The studies on computer icon taxonomy started in line with GUI. It was pointed out in the purpose to clarify the characters of kinds of icons applied in computer interface and tried to find the common attributes among these icons in varied appearance. The common attributes were supposed to support the creation of icon-based GUI in a diversified way. The icon taxonomy has been explored and improved for about thirty years and it formed progressively into three branches based on three different but related criterions. Under each branch, a group of icon taxonomy was proposed by different researchers. Although the findings in one group came out from various theory foundations, they built up a complete branch of taxonomy because of the overlap originating from common criterion. In this section, the computer icon taxonomy will be illustrated in the view of three criterions to present the evolution stage in the field.

2.1. Icon taxonomy based on physical appearance

The studies on icon taxonomy emerged between 1980s and early 2000s. Physical-appearance-based criterion has been widely accepted and applied for icon taxonomy since a long period. Here the physical appearance of icons refers to the relevance between iconic representation and represented object. Physical appearance of icon was the first proposed criterion in icons taxonomy and derived tens of related classification methods. Although the icon category titles of these methods differed from each other, they all implied the relevance between iconic representation and represented object as criterion.

Tracing back to Lodding's [11] icon classification, three categories were proposed: representational, abstract and arbitrary. *Representational icons* were defined as examples of general representing object. For example, an image of petrol pump represents a petrol pump. And *abstract icons* are those express the concepts rather than to display the object itself: an image of a broken glass to represent "fragile". The third category of icon naming *arbitrary* was explained as the icons created and designed under certain convention.

In 1986, two papers concerning icon classification were published: Gittins and Gaver. Gittins [12] analyzed icon classification based on form, type and color, but mainly focus on the form of icon. Two categories of icons were suggested by Gittins: associative icons and key icons. *Associative icons* were defined by the icons not only allowing computer users to identify the represented object but also to infer their graphical attributes. Gittins gave an example of this kind of icons using an image of mail trays and arrows to indicate incoming and outgoing email. Further subcategories of associative icons were also mentioned by literal icons and abstract icons. However the author did not explain them in details. Another category, *key icons* were those provide cognitive implication from representing objects. They were as well divided into mnemonic icons and arbitrary icons. The mnemonic icons were able to be inferred by sub-text, for example a guillotine to represent "execute"; while arbitrary icons could not be inferred.

Another paper produced in this year by Gaver [13]. Gaver proposed three categories for computer icons: nomic, symbolic and metaphorical. He defined that the *nomic icons* have a photographic relationship with represented objects, which is similar to the representational icons of Lodding's. And *symbolic icons* have an arbitrary relationship with representing object that requires be learnt and understood. Finally he illustrated that *metaphorical icons* use a feature of icon to represent a whole thing, such as using knife and fork to represent a restaurant.

One year later, Lindgaard et al. [14] classified icons according to a simple criterion: whether abstract or depictive. *Depictive icons* resemble exactly the representing objects, named purely pictographic; while *abstract icons* is on the contrary, entitled purely symbolic. Besides these, they created a third category, mixed icons, referring to the icons have both abstract and depictive elements.

Three important studies on icon taxonomy occurred in 1989 in order to present a new classification method of computer icons but somehow related to former ones [15–17]. Rogers proposed an icon classification paying emphasis on the function and form of icons. She also discussed theoretical issues of how computer users utilize information in icon-based interface displays when performing a task. Rogers in her research identified four icon types: resemblance, exemplar, symbolic and arbitrary. Rogers described *resemblance icons* as icons that present their underlying referent using an analogous image; she gave the International road sign for falling rocks as an example. Rogers defined her second icon type, *exemplar*, as icons that show only the most central attributes of an object, such as a knife and fork for a restaurant sign. Rogers defined her third icon type, *symbolic*, as icons whose function is to 'convey an underlying referent that is at a higher level of abstraction than the image itself'. The image of a broken wine glass to imply fragility was offered as an illustration of this icon type. Finally Rogers