ICED13
INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED13
19-22 AUGUST 2013, SUNGKYUNKWAN UNIVERSITY, SEOUL, KOREA

USER ACTIVITY ANALYSIS FOR DESIGN FOR AFFORDANCE

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ABSTRACT
User interaction with a product is modeled based on user activity composed of perception, judgment and action together with affordances given by the product. Based on user assessment on each step of perception, judgment and action of an activity, inter-relations between specific activity and its affordance feature of the product can be scrutinized. Those affordance features of the current product could be redesigned exploiting hints from other affordance features of the corresponding affordance in the repository. This paper introduces the design for affordance method using activity analysis. An illustrative example is presented where a practicing product designer designed new affordance features for those affordances of activities with poor evaluations hinted from other affordance features in the repository for the corresponding affordances.

Keywords: activity anaysis, design for affordance, affordance feature repository, design methods, user-centred design

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1 INTRODUCTION

1.1 Background

When using a product/service, the way people interact with the product/service is largely affected by how people perceive or interpret the designed features. This means that human-product/service interactions can be significantly influenced by the physical characteristic of the product/service and also the manner in which they are presented to human users. To properly understand the interaction patterns or mechanisms of human and a product/service, it is essential to know how the designed product/service features and their presentations are perceived, judged and thus acted-upon by the users. In this respect, importance of a reliable methodological frameworks has been recognized in terms of affordance and affordance features for effective product/service design (Norman, 2002), (Kim et al., 2012a). However, there have been few systematic methods supporting design for affordance.

An affordance is often defined as a message that a product/service provides to users in order to induce a meaningful action in the process of an activity (Gibson, 1979), (Norman, 2002). In addition, an affordance feature can be conceptualized as a structural element of the product/service that realizes the affordance (Kim et al., 2009). The characteristics of product/service properties that induce meaningful affordances play critical roles in making human-product/service interactions successful. Thus, properly presenting appropriate affordance features as structural elements of a product/service must be a key to effective affordance design for human-product/service interactions.

Another important thing to note is that the perceived features may vary according to the context as the messages carried by affordance features are not independent with the context (Kim and Lim, 2009). In other words, the functioning of affordance features in the human-product/service interaction can be largely altered by the way that a user perceives and judges the immediate social and physical environments. Users' interpretation of certain affordance features for the designed messages in human-product/service interaction seems to be a contextual issue which needs to be approached from a human activity system perspective (Kim et al., 2008).

There have been efforts in developing methods of design for affordance. Galvao and Sato (2006) developed a tool which helps to analyze interactions between functions and tasks in terms of affordance in a matrix format. Maier et al. (2007) introduced an affordance-structure matrix to identify affordances embedded in the structural parts of a product. The matrix illustrates relationships between affordances and the related product components. Researchers also attempted to investigate affordance features along with the relationship patterns of geometric attributes and human activities such as pushing, pulling, turning and tilting (Murakami et al., 2006). There is also a model which guides to find out affordance features of a simple medial device, a portable infrared crystal lamp (Kim et al., 2011).

Through empirical studies on typical household products, Kim et al. (2008a) showed that affordance features as structural elements of a product/service system can be classified by the manner of how they are perceived by the users. A study showed that affordance features of existing products can be compiled to provide help in designing new products. In the study of Lim (2011), affordances have been identified through the task-function interaction method of Galvao and Sato (2006). Based on the structural elements of the device identified by state changes in user activity observation, affordance features have been identified. Affordance features of existing artifacts can be compiled to provide help in designing new artifacts. A methodological framework for design for affordances has been proposed applying a repository of affordance features (Kim et al., 2012b). Researchers generally agree that rigorous analytic models are necessary to explore the original intents of affordance messages designed in the product/service features (Koutamanis, 2006).

1.2 A Framework of Design for Affordance Using Activity Analysis

The proposed method of design for affordances has been developed along with Context-based Activity Model (Kim et al., 2010) and PJA (Perception-Judgement-Action) activity model (Kim and Hong, 2012c) as these conceptual models guided activity-focused approaches to the identification of affordance and affordance features. The proposed method consists of four major steps. First, affordances are identified with regard to the given design problem. This can be done in a few different ways. Using Function-Task Interaction (FTI) method (Galvao and Sato, 2006), affordances can be identified in relation to user tasks, activities and functions of the product/ service. Alternatively,

affordances can be also approached by user activities. The output of the first step is the list of affordances.

Based on the identified affordances through FTI, the second step proceeds to affordance feature identification. Here, affordance features are defined in relation to the product features. And then, in the subsequent step, Affordance Feature – Activity interaction matrix is composed by linking affordance features to user activities, which are the AF-Activity interaction points. This activity-focused analysis is to explore the relationship between affordance features of product/services and user activities in terms of user knowledge, expectation, experience values in context (Kim and Hong, 2012c). This matrix helps to investigate AF-Activity interactions quantitatively and qualitatively from three analytic views: perception, judgement, and action. A cycle of Perception-Judgement-Action (PJA) serves as a unit of analysis which enables researchers to visualise the product/service-human relations with numerical information indicating how and to what extent each product/service feature involves the Activity-AF relationship. Furthermore, the equipped Context-based Activity Model (CBAM) guides researchers to take account of the environmental and situational factors meaningfully relating to the Activity-AF interactions (Kim et al., 2010).

Through the analytic procedure, the method enables researchers to identify affordance features with problems in a product/service, which are not properly functioning according to the design intention. From the activity side, it finds out the activity counter parts associated with each AF in a product/service. The analysis presents reasons of the problems and the extent to which the problems are in the AF-Activity relationship.

The proposed method can be used as a tool in evaluating affordance features in a product/service in order to improve the problems present in the current design or to generate ideas for new design. Therefore, supplying quantified and interviewed data to the AF-Activity matrix analysis, researchers can approach the affordance feature and activity interaction on various dimensions – at each interaction point separately, or integratively over the interaction points from either activity side or AF side. The quantified and interviewed data help to analyze how and to what extent each affordance feature facilitates or interferes with user activities in the Perception-Judgment-Action (PJA) interaction process. On the whole, the AF-Activity matrix analysis equipped with empirical data guides to objectively determine product/service features with problems and how to deal with them for a better design.

Figure 1. A framework of design for affordance using activity analysis

With the information from AF-A interaction matrix, the method takes to the next phase, which is the application of affordance feature repository to decide details about a redesign or new design of a target AF-Activity interaction. In the AF repository, a large pool of affordance feature alternatives are stored with detailed information about their elaborate applications and contexts. Affordance features are selected by considering their design constraints and contexts of application. Before using the repository, a thorough function and task analysis is a prerequisite for proper identification of affordances associated with target affordance features. Especially when more than one stakeholder involves in AF-Activity interactions, which is a typical situation of service design cases, activities of all relevant stakeholders involved in the interaction need to be identified. In this process, analogical reasoning from the source affordance features into the target affordance features can be done in various ways in correspondence with designer's design approaches.

Applying the quantitative and qualitative data collected from various methods of user observation and interview in the form of Activity-based analysis, researchers can visually map out a matrix of affordance feature and activity relations. As the matrix presents the relations between affordance features and user activities from the interaction unit of Perception-Judgment-Action, it enables to find out the nature and patterns of the affordance feature and activity relations from both the affordance feature and activity sides in terms of interaction intensity, duration, frequencies and etc. Furthermore, the matrix contains the psychological attribute information as to the activity (PJA) process which eventually helps to understand 'why' questions about the Activity-AF relationships.

2 A CASE APPLICATION – STEAM IRON

2.1 Data Collection

The steam iron is a home appliance. This device is a stand type iron with a large water tank and steam-oriented system. It is different from a heat-oriented electric iron in a triangular shape. As shown in Figure 2, the small size ironing part with the handle and long rubber hose make user easy to iron with standing position. The holes on ironing surface give off steam to fiber, and using hanger and clothespins clothes are fixed flatly.

Figure 2. Steam Iron

For observation of user behavior of the steam iron, we observed user behavior of 5 participants, who used the steam iron for the first time. At the start phase of user observation was the video recording of the participants doing activities with the steam iron. It was to collect primary data of the user-product interactions. The obtained data contained various information of the users, the behavior, the environment as well as the activities. The video recording covered general views and movements of the users in the setting and also specific views of the behavior. The collected data was analyzed under the proposed methodological framework for the affordance and affordance feature analysis.

Based on the recorded data, we identified a general task flow in the use of the steam iron. The user behavior was divided into nine tasks such as installation, filling up with water, connecting power, adjusting height of stand, ironing top clothes, and ironing bottom clothes, and etc. Then, the identified tasks were used as a basis of pointing out 44 activities like moving, positioning, separating the water storage from body, opening the cover of the water storage, filling the water storage with water, closing the cover of the water storage, and etc.

2.2 Analysis and Redesign

Function Decomposition

The function decomposition of the steam iron revealed 49 functions including stand on surface, import human hand, import human foot, move body, detach liquid storage, open liquid storage, stand liquid storage, import liquid, and etc.

Function Task Interaction and Affordance

FTI analysis explored 33 affordances from 49 functions and 44 activities from the user-product interactions. To mention some of them, they are: Pull-ability, Roll-ability, Stand-ability, Hand grasp-ability, Separate-ability, Hold-ability, Rotate-ability, Unfasten-ability.

Affordance Feature - Activity (AFA) Interaction Matrix

Applying the Activity-based framework, the researchers analyzed quantitative and qualitative data from video recordings and interview. For the measures of each Affordance Feature and Activity (AFA) interaction, the researchers used the Perception-Judgment-Action (PJA) model. Figure 4 presents the overall output of the AFA interaction matrix. The matrix contains the information of the activities in

sequence on the top row arranged by the categorization of the tasks. The matrix also contains the information about the affordance features on the vertical side with individually assigned AF codes. In the matrix, each AF-A interaction cell is further divided into three rows providing the numeric data reporting Perception-Judgment-Action measures. The PJA measures were coded in the scale from 0 to 2 according to the difficulties in perceiving, judging or conducting an appropriate action in relation to each affordance feature on the column side.

The affordance feature-activity interaction matrix was analyzed with contents of individual user interviews as the results are shown in Figure 3. In the matrix, only those AFA interaction points where actual interactions occur are marked with the measured PJA scores. For the cells with less than 2.0 average score of any perception, judgment or action measure, the corresponding AFA relation is red colored indicating the presence of affordance problem; the affordance feature fails to afford the user activity due to any difficulty in perceiving, judging or acting on the product feature. Furthermore, the attached descriptive texts to the red-colored cells explain the reasons of the failure provided by the participant users in the case study. The cells with gray color denote that the affordance feature properly functions inducing user activity as purposefully designed.

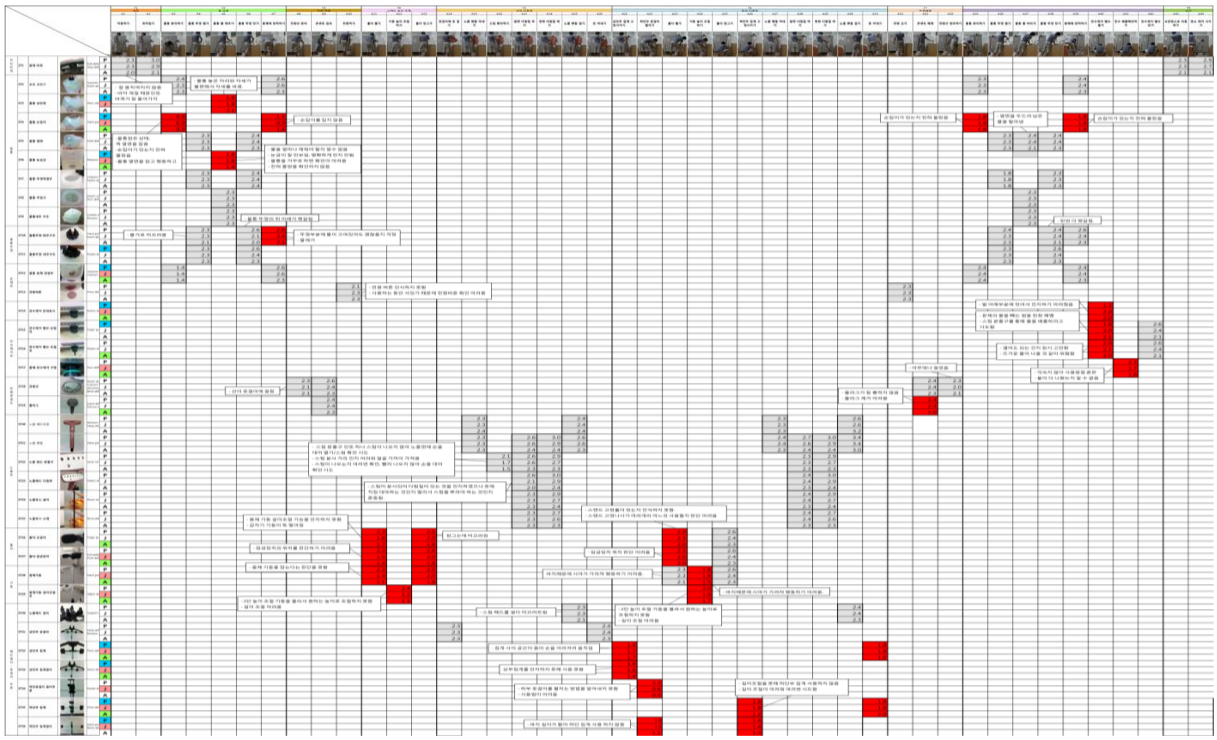

Figure 3. Steam Iron AFA Matrix

As each activity interacts with several affordance features while each affordance feature does with many activities, the PJA scores for each activity or affordance feature can be averaged for analysis. Thus, in the matrix, the bottom row and the right most column show the overall average scores which help to rank the activities or affordance features in terms of problem severity. The qualitative information linked to a text box provides affordance rationale for improvement or redesign of the AF-Activity relations.

In the case of steam iron, 109 interaction points were identified from 36 affordance features and 44 activities. Among the interaction points, 31 AF-Activity interactions from 17 activities and 18 affordance feature of the steam iron occurred of one or more problems in terms of participants' perception, judgment, or action during the use of the product. The AF-Activity interactions with problematic PJA are marked red. To mention some of them: 'changed posture due to uncomfortable position and the water container location', 'failed to recognize the grip', 'held a side of the water container', 'no indication of the appropriate amount water to pour', 'hard to read the water measure', 'removed water on the lid', 'difficult to find it as located underneath the container', 'failed to perceive the valve plug', 'hesitated an action due to the likelihood of water boiling out', 'confused of the usage', and etc.

Affordance Feature Repository and Redesign

The affordance features with AF-Activity interaction problems in any of the perception, judgment, or action (PJA) measures were regarded as the targets to improve through redesign. For the ideation of design alternatives through utilization of affordance feature repositories in the subsequent phase, qualitative information from the interviews was used to guide the designers forward getting answers to the reasons of AF-Activity relational problem occurrences.

Thus, to come up with design alternatives as for 18 affordance features with PJA interaction problems, designers used affordance feature repositories. For the use of AF repositories, designers can input a name of affordance or of affordance feature directly and then select one or more of design alternatives suggested from the AF repository database. Then, they applied techniques of analogical reasoning based on the AF suggestions in order to come up with appropriate ideas of redesign. In this process, designers advance with the AF suggestions to produce concrete ideas to solve the identified AF-Activity relational problems. They had to continually consult the findings of user interviews and PJA scores in order to make reliable design decisions. Figure 4 presents example sketches of redesigned affordance features in the case of the steam iron as the outcome of the analysis and AF repository application.

Figure 4. Using affordance repository new design of steam Iron

For example, the bar of the steam iron (ST28) was identified as one of the 18 affordance features with the AF-Activity relational problem of 'Hand grasp-ability'. The involved activities were 'unlocking holder', 'adjusting height of bar' and 'locking holder'. A user interview revealed that participants expressed a problem in using the bar because they "couldn't judge to hold the bar". Thus, a designer browsed affordance features related to 'hand grasp-ability' in the AF repository, and came up with a number of alternative AF suggestions. Among various affordance features, the designer decided to put a handle on the bar with a shape of supporting an easy grasp. The designer attached to the bar a grasping handle with a depressed surface.

Figure 5 shows the final sketch of the redesigned bar and an illustrative screen view of AF repository use – specifically focusing on 'hand grasp-ability' affordance in the suggested affordance feature from the repository.

3 SUMMARY

This paper has briefly introduced a method of affordance design together with a case study applying the developed method to a steam iron design project. Synthesizing separately developed methods into one framework, the present paper demonstrated the steps of foci from the product features (Function Decomposition/ Function Task Interaction), product-user relations (Affordance Feature and Activity Interaction Matrix), analogical investigation (Affordance Repository), and finally back to the product features (Affordance Feature Design). Through the procedure, the proposed model enabled researchers to not only identify and prioritize affordance problems associated with certain product features but also provided a guide in searching for research-based design solutions for better affordance design. During the solution-seeking process, the information produced from the Affordance Feature and Activity matrix analysis guided the researchers to pertinent analogies for design solutions.

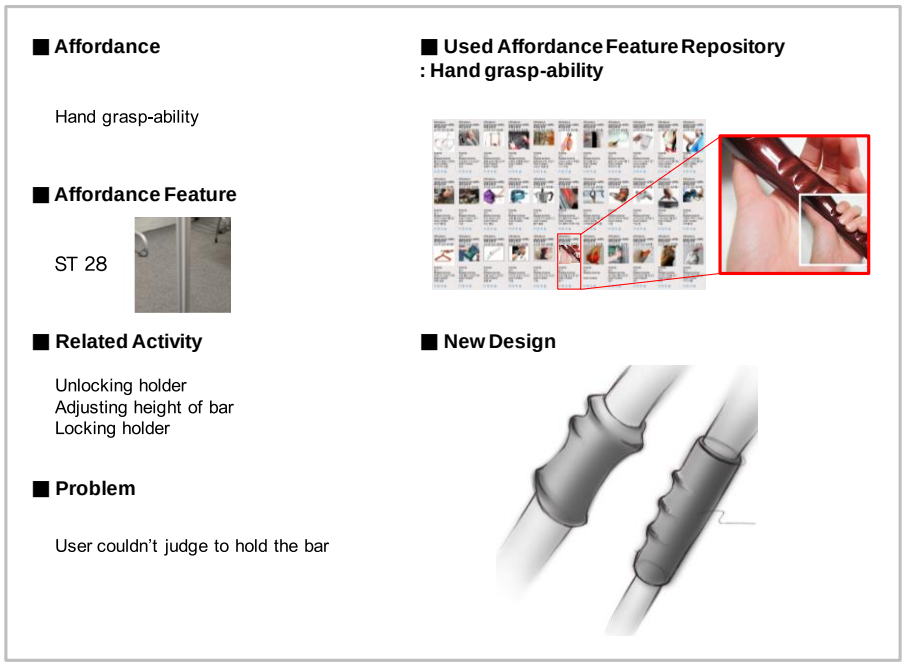

Figure 5. Using affordance repository new design of steam Iron – ST28

Applying the activity-based analysis as the key to the model, the researchers found that the proposed model was a useful research tool for design for affordance. However, since the method requires a thorough preparation and analysis on video recordings and user evaluation of a large number of AF-Activity interaction points, the procedure can be laborious. Computer-assisted video analysis tools and interviews may help to mitigate this issue. This paper described a case example applying the method to a product design. Despite a preliminary stage of the method development, it was an meaningful step in advancing for a pragmatic tool supporting design for affordance. With more applications to various types of products and also service processes, the method reserves improvements.

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