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# Persuasive Design for Products Leading to Health and Sustainability Using Case-Based Reasoning

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Academic Editors: Beatriz Junquera and Marc A. Rosen
Received: 13 February 2016; Accepted: 28 March 2016; Published: 30 March 2016

**Abstract:** This study proposes a novel method for facilitating product design that persuades users to have more bodily movements for both health and energy harvesting by using concepts of case-based reasoning. A domain knowledge model for case-based reasoning is proposed to explain how design and technology can help persuade users to perform target behavior. There are five groups of attributes in the model including target behavior, design principles, design techniques, applicable technology, and users' motives and ability. With the model, knowledge from more than 98 cases are extracted to form a case library. To find better persuasive means for different user groups, significant users' motives and ability are identified for different target users by using regression models which result from a questionnaire survey of local potential users. A case-based method with a six-step procedure is proposed to find some useful suggestions from retrieved cases by specifying target users and target behaviors. An illustrative example is presented to demonstrate the application potential of the proposed method.

**Keywords:** Case-based reasoning; domain knowledge model; persuasive design

## 1. Introduction

Recently, product design that can persuade users to change behavior has caught much attention. One of the application areas is sustainable product design because more sustainable behaviors need to be encouraged so that sustainability can also be achieved in product use stage instead of simply achieved in manufacturing stage. For example, Herring and Roy [1] reported that a "rebound effect" appeared when energy saving produced by energy efficient products is taken back in the form of higher consumption since many consumers, knowing that using the products (e.g., light bulbs) now costs less, are less concerned about turning them off. The behavior therefore "takes back" some of the energy savings that are supposed to be achieved by green products. Because of the above "rebound effect" phenomenon, design for sustainable behavior (DfSB) that persuades users to have more sustainable behavior was discussed most anxiously recently. Good example literatures related to DfSB include Lilley [2], Wever *et al.* [3], Lockton and Harrison [4,5], Fogg [6,7], Oinas-Kukkonen and Harjumaa [8], and Pettersen and Boks [9]. Among these studies, different terminologies other than DfSB were used including design with intent (DwI), persuasive technology (PT) and persuasive system design (PSD). However, the essence of these studies are similar, namely proposing a general framework or methodology for product design to persuade users to change their behaviors. However, explicitly making design suggestions for all kinds of product design is not easy because behavior change involves various psychological and social factors (Lockton *et al.* [10], Webb *et al.* [11], Daae and Boks [12]). Shih and Hsin [13] tried to overcome the difficulty in establishing relationship between design and behavior change based on two ideas: (1) establishing relationship may be easier if one narrows down the scope and focuses on persuasive design for a specific type of products and (2) instead of establishing explicit rules to describe the relationship, case-based reasoning (CBR) may be helpful

by properly retrieving past successful cases and getting useful suggestions. Shih and Hsin [13] and Shih and He [14] hence narrowed down the scope and worked on a type of products which require more human bodily movements.

This study also focuses on persuasive design for the type of products and the reasons of selecting this type of product design are twofold: (1) bodily movements could serve as a source of energy harvesting (or called human power) that helps reduce conventional energy consumption and (2) bodily movements produced by skeletal muscles that requires energy expenditure often brings benefits in health as well as rehabilitation. Making this type of products successful could also be recognized as a mean of leading to a lifestyle of health and sustainability (LOHAS), which was first introduced by Ray and Anderson [15]. Health and sustainability could serve together as product goals. In other words, sustainable products could be more persuasive if it is also good for health. To get a brief idea of the designated type of products, one can imagine a combination of two popular types of products: (1) exergaming products like Wii by Nintendo or X-Box Kinect by Microsoft and (2) energy harvesting devices like Eco-Power fitness machines by SportsArt. It would be interesting to have more products combining the two and get fun, health and clean energy simultaneously.

In order to obtain a useful method, two methodologies, CBR and PT, are integrated to facilitate the persuasive design for the aforementioned type of products. Firstly, some concepts of CBR including setting domain knowledge model, retrieving, and reusing cases are utilized to extract knowledge and experience from existing cases (Aamodt and Plaza [16], Aha [17]). Secondly, the theory and methods of PT are adopted for building a domain knowledge model and facilitating product design. In this study, the domain knowledge model contains causal relationships between design goals of products and means to achieve them. Information of existing cases are extracted and stored in terms of attributes of the domain knowledge model. Lastly, a case library is constructed accordingly and designers can therefore get useful design suggestions from retrieved cases.

The domain knowledge model is constructed by integrating the research results such as persuasive technology proposed by Fogg [6,7], Fogg and Hreha [18], persuasive system design by Oinas-Kukkonen and Harjumaa [8] and design with intent by Lockton *et al.* [5,19]. These methods have been used in facilitating software design as well as product design, for example, 28 design principles presented in PSD were used in helping information system designs that encourage people in reducing obesity (Lehto and Kukkonen [20], Purpura *et al.* [21]). Shih and Hsin [13] studied the literature and proposed a preliminary domain knowledge model that includes target behavior, design principle, design technique and applicable technology to facilitate persuasive design. However, whether persuasion is effective often depends on whom (target users) we want to persuade. In this study, prior information of target users is considered important including knowing their motives and lack of abilities for behavior change, which are the two key factors of the behavior model proposed by Fogg [7]. This study includes users' motives and lack of ability in the domain knowledge model, thereby expanding and enhancing the model power in describing the relationship between behavior change and product design, especially when target users are known. The benefit of including these two factors is obvious because, by knowing target behavior and target users with identified motive and ability, more appropriate cases could be retrieved and more useful suggestions could be provided. In terms of case-based reasoning, target users' motives and lack of ability provide additional information in searching for "similar" cases.

In Section 2, a new domain knowledge model is proposed which includes five groups of attributes: target behavior, design principles, design techniques, applicable technology, and user's motives and ability. Section 3 describes a case library containing more than 98 cases with information of the five groups of attributes. In Section 4, to learn about motives and ability of different users, a questionnaire survey is conducted to gather local users' basic information (about who the users are) and users' motives and ability in conducting exercises and using products that require bodily movements. From the responses of the survey, regression models were built to estimate levels of user's motives and lack of ability by knowing user's basic information like age, gender, habit of exercise, and so on. In Section 5, a six-step procedure is proposed to find useful suggestions from retrieved cases by

choosing either inspiration mode or prescription mode. To efficiently search for cases, a searching engine based on software ACCESS is written to retrieve similar cases and get useful suggestions by specifying target behaviors and target users while motives and lack of ability of the target users are identified using the regression models. At the end, an illustrative example is presented to demonstrate the application potential.

## 2. A Domain Knowledge Model for Persuasive Design

In applying case-based reasoning in persuasive design, a domain knowledge model is needed to describe the relationship between target behavior and design means and extract past experiences from cases. The model should contain knowledge that could be used to answer questions like what kinds of design would influence user behavior leading to bodily movement, what types of design or technology used could be more effective in persuading users, and what types of design and technology used in a product would be more effective in persuading a specified group of target users.

To establish the domain knowledge model, this research begins with reviewing relevant literatures and defining the scope. A summary of the research results in the literature helps define structure and attributes of the model. However, since this study does not attempt to develop a method for general use and focuses on a specific type of products, modification and integration of the results in the literature are needed. The model consists of five groups of attributes while the detail attributes are defined based on a literature review and an investigation of collected cases. The resulting domain knowledge model includes the following five groups of attributes:

(1) Target behavior involving bodily movements
(2) Motives and lack of ability of users
(3) Design principles modified from the list in PSD
(4) Design techniques modified and extended from the list in DwI method
(5) Technology (hardware) used for effective persuasion.

The following includes a detailed description of the five sets of attributes contained in the proposed domain knowledge model.

(1) Target behavior. Referring to the work of Fogg and Hreha [18] that explicitly listed out target behaviors, this study proposes nine types of target behavior by defining three types of behavior change and three types of bodily movements. Three types of behavior change (behavior flavors called by Fogg and Hreha [18]) include: (a) users try out new behavior, (b) users re-perform beneficial actions or familiar behavior, and (c) users increase behavior intensity. Since the essence of this study is to persuade users into more bodily movement, it is crucial to identify which parts of body exercises, which may be classified as an upper, lower limb or whole body movement. The two classifications result in totally nine types of target behaviors shown in Table 1, which offers an objective way to view different bodily movements and assists in retrieving cases for further applications.

**Table 1.** Attributes in the domain knowledge model.

| Type of Attributes | Attributes | | |
|---|---|---|---|
| Target behavior | Upper limb/new behavior | Upper limb/Familiar behavior | Upper limb/Increase intensity |
| | Lower limb/New behavior | Lower limb/Familiar behavior | Lower limb/Increase intensity |
| | Whole body/New behavior | Whole body/Familiar behavior | Whole body/Increase intensity |
| Motives | M1. Visual pleasure | M2. Audio pleasure | M3. Physical excitement |
| | M4. Learning | M5. Health | M6. Accomplishment |
| | M7. Fashion | M8. Cooperation | M9. Competition |
| | M10. Sustainability (energy generation) | | |
| Ability | A1. Saving time | A2. Less physical effort | A3. Less brain cycle |
| | A4. Less social deviance | A5. Turning behavior to routine | |

(2) Motives and lack of ability of users. Fogg [7] stated that motive, ability and trigger are three factors for behavior change. Since more understanding of users motives and lack of ability could help get better design suggestions, these two factors are included in the domain knowledge model as well as case profiling. For each case, why (motives) and how (ability) target users use the case product are described in the case profile. Because of this additional information, in retrieving cases, with given target users' motives and lack of ability, more appropriate cases and useful suggestions can be found. By referring to Fogg [7] and the information of collected cases, ten types of motives and five types of ability are defined and shown in Table 1. Section 4 shows how regression models are established to find different motives and abilities for given target users.

(3) Design principles: The 28 design principles presented in Persuasive System Design (Oinas-Kukkonen and Harjumaa [8]) provide a potential list for the attributes. However, since this study only focuses on the underlined product design, not all design principles would be appropriate. After checking with collected cases, 17 out of 28 design principles were found to appear in the 98 cases and are presented in Table 2.

**Table 2.** Design principles for the underlined product.

| Number | Design Principle | Number | Design Principle |
|---|---|---|---|
| A | Reduction | J | Suggestion & Reminders |
| B | Tunneling | K | Similarity |
| C | Tailoring | L | Liking |
| D | Personalization | M | Social role |
| E | Self-monitoring | N | Social learning |
| F | Simulation | O | Social Comparison |
| G | Rehearsal | P | Normative Influence |
| H | Rewards | Q | Social Facilitation |
| I | Praise | | |

(4) Design techniques. The 101 design techniques from DwI method (Lockton *et al.* [5,19]) are examined and cross checked with the information of case products related to this domain. Forty-three out of the 101 design techniques are used in the 98 cases. In addition, six new design techniques are added by this study. So, there are in total 49 design techniques shown in Table 3 that help with the underlined persuasive design. The six new design techniques suggested by this study are marked by "*", including full-recording, virtual reality, energy feedback, virtual rewards, system praise and public exhibition which are somewhat different from the 101 design techniques.

**Table 3.** Design techniques for the underlined product.

| Number | Design Technique | Number | Design Technique |
|---|---|---|---|
| A1 | Hiding things | G1 | Rehearsal |
| A2 | Feature Deletion | H1 | Energy Feedback * |
| A3 | Simplicity | H2 | Virtual Rewards * |
| B1 | Angles | I1 | System praise * |
| B2 | Conveyor belts | I2 | Social Praise |
| B3 | Mazes | J2 | Conditional warning |
| B4 | Positioning | J3 | Serving suggestion |
| B5 | Pave the Cowpaths | J4 | Are you sure? |
| B6 | Interlock | K1 | Similarity |
| B7 | Implied Sequence | L1 | Color associations |
| B8 | Bundling | L2 | Prominence |
| B9 | Matched affordance | L3 | Seductive atmospherics |
| B10 | Levels | L4 | Emotional engagement |
| B11 | Kairos | M1 | Personality |
| C1 | Who or what you are? | N1 | Expert choice |
| C2 | Where you are? | N2 | Public Exhibition * |

**Table 3.** *Cont.*

| Number | Design Technique | Number | Design Technique |
|---|---|---|---|
| D1 | What you have done? | N3 | Social proof |
| D2 | What can you do? | O1 | Competition |
| E1 | Feedback through form | O2 | Cooperation |
| E3 | Progress bar | P1 | Commitment & Consistency |
| E4 | Real-time feedback | P2 | Assuaging guilt |
| E5 | Summary feedback | Q1 | Do as you're told |
| E6 | Full-recording * | Q2 | Recognition |
| F1 | Simulation & Feedforward | Q3 | Peer feedback |
| F2 | Virtual Reality * | | |

Note: * means the design technique added by this study in addition to those recommended in DwI.

(5) Technology/hardware. Technology is another major ingredient in persuasive technology. Fogg [7] pointed out that technologies can play roles in three ways, as tools, media, and social actors, thereby presenting various functions and influencing behaviors differently. As a complement to design means (software), applicable technology (hardware) is therefore included in the domain knowledge model because it often works together with design means in persuading people to change behavior. Therefore, it is important to sort out the technologies that are used in the collected case products. Table 4 presents 18 modern technologies, mainly information and communication technologies, including video display, recording, audio player, health condition detecting, vibration, motion sensor, internet connection, energy harvesting, *etc*.

**Table 4.** Applicable technology for the underlined product.

| Number | Applicable Technology | Number | Applicable Technology |
|---|---|---|---|
| T1 | Display | T10 | Internet |
| T2 | Record | T11 | Fitness equipment |
| T3 | Speaker | T12 | Energy harvest |
| T4 | Health monitor | T13 | Storage device |
| T5 | Mobile and remote control | T14 | Software for stratified content |
| T6 | Lighting | T15 | Software for increasingly challenging content |
| T7 | Vibration | T16 | Avatar types |
| T8 | Motion sensor | T17 | Air mask |
| T9 | 3D virtual reality | T18 | GIS or GPS service |

## 3. A Case Library with Case Products Requiring Bodily Movements

A case library is built up with case products that are gathered to present actual examples of the designated type of products. These case products persuade users to have bodily movements, which is produced by skeletal muscles that require energy expenditure. The goal of case products often relate to health or sustainability (human power energy harvesting) domains, example domains include healthcare systems, physical therapy, fitness games, exercises and fitness, and energy harvesting. Most of the cases have applied modern information and communication technologies. Among the cases, there are 37 cases that apply energy harvesting technology (*i.e.*, T12 in Table 4), thereby indicating that designers could retrieve useful knowledge from some cases with energy harvesting.

A total of 98 cases were collected for constructing the case library and major sources of these cases are from websites like Yanko designs, Gizmag and Inhabitant that introduce new product, fitness products and other ingenious designs from modern designers. Other sources of cases are reviewing literature of different research that matches the scope of this study. For each case, case profile must include information like name, picture, producer and information of the five sets of attributes defined in Section 3. Table 5 summarizes the five sets of attributes in the domain knowledge model with a total number of 102 attributes for each case profile. From the experience of gathering complete and necessary information regarding the five sets of attributes, there follow some notes and questions to ask in establishing a satisfactory case profile.

**Table 5.** Numbers of different attributes.

| Type of Attributes in a Case | Number of Attributes |
|---|---|
| Target behavior | 9 |
| Motives | 10 |
| Lack of ability | 5 |
| Design principle | 17 |
| Design technique | 43 |
| Applicable technology | 18 |
| Total number of attributes | 102 |

(1) Which parts of body physically move and what kind of behavior change are involved in the case? Upper body, lower body or whole body? To a user, is it a new behavior, familiar behavior, or a behavior with higher intensity? If there are multiple types of behavior changes in one product (like many games provided in Wii), multiple case profiles can be set up for one product, since multiple experiences of persuasion may be extracted.

(2) What users' motives are expected by the designer for using the case product? What kind of ability for behavior change is the case product enhancing? To answer these questions, one needs to know who the target users of the case product are. If there are multiple groups of target users, all possible motives and abilities should be included in the case profile.

(3) Identify which design principles are used in the case product referring to the 28 candidate design principles suggested in Onis-Kukkanon and Hajumaa [8]. Modifying and adding new design principles are allowed but require a careful review. After carefully reviewing the 98 cases, 17 design principles are found useful. As new cases are added in the future, the number of useful design principles may increase.

(4) Identify which design techniques are used in the case products referring to the 101 candidate design techniques provided in Lockton *et al.* [19]. Modifying and adding new design techniques are allowed but need a careful review. After reviewing the 98 design cases, 43 out of 101 design techniques are found useful while additional six design techniques are proposed by this study.

(5) Identify what kinds of modern technologies, mainly information and communication technologies, are used in the case products. As mentioned earlier, 18 types of technologies are found in the 98 cases.

After making case profiles, indexing was conducted to transform the attribute descriptions into indices for easier searching and retrieving. Indices break down the descriptions of attributes into codes and help sort out the differences between cases, which is very important for case search and retrieval. In this study, 102 binary variables are assumed to denote the 102 attributes (see Table 5) and represent the characteristics of each case. Twenty-four indices of the first two groups of attributes denoting target behavior and target user are employed as input to find "similar" cases, and after case retrieval, the remaining 78 attributes in the retrieved cases offer suggestions to inspire a new product design.

## 4. Regression Models for Identifying Target Users' Motives and Lack of Ability

It is important to identify significant motives and abilities of different types of users so that designers can find useful design suggestions to effectively persuade the designated target users. In the following discussion, knowing target users is treated equivalent to knowing their motive and ability for using the underlined product. If the relationship between characteristics of users and motive and ability is established beforehand, product designer can use the relationship and search for useful cases by simply indicating who the target users are. Regression models are built to describe the relationship between user characteristics (independent variables) and their motives and lack of ability (dependent variables) based on the results of a questionnaire survey. The survey collected information about people's age, gender, education, vocation, time and frequency of doing exercise, motive, and lack

of ability to know more about who the users are and their motives and lack of ability when they use products that require bodily movements.

There were more than 45 questions, which were divided into four groups as follows: (1) respondents' basic information (demographical variables) such as age, gender, education and vocation; (2) health condition and exercise habit including health condition, frequency and average time for weekly exercise; (3) motives for using products requiring bodily movements. A typical question is like: do you agree providing audio device (like playing music) is important in using a product that requires bodily movements? Respondents were asked to provide rating of agreement on the statement with Likert 5 point scale, and (4) lack of ability. A typical question is: If the product has some devices to help you reduce complicated operation, would you be more willing to use it? Questions in groups (1) and (2) were used to identify who the users are, while questions in groups (3) and (4) include various measures of users' motives and lack of ability for using products that require bodily movements. The detail questionnaire design could be found in Sun [22].

The questionnaire survey was conducted in January 2014 in Taiwan. More than 289 responses were collected while 250 responses were identified as effective responses. Some descriptive statistics of the respondents are as follows:

(a) gender (male: 51%; female: 49%),
(b) age (under 25: 40%; 25%–40: 21%; 40%–60: 35%; above 60: 4%),
(c) self-assessed health condition (bad: 3%; alright: 38%; good: 44%; very good: 15%),
(d) average times of exercise per week (less than 1 time: 14%; 1–2 times: 48%; 3–5 times: 30%; more than 6 times: 8%), and
(e) average time per week (less than 30 mins: 47%; 30-60 mins: 37%; more than 60mins: 16%).

From the responses of the questionnaire survey, statistical significance tests and coefficient estimation can be conducted for the regression models with seven independent variables measured in questions from groups (1) and (2) and 15 dependent variables measured in questions from groups (3) and (4). For each motive or ability, a regression model was built and tested for significance. For example, M1 stands for the first motive in Table 1: pursuing visual pleasure (ranging from 1 to 5 where 5 means the strongest) and seven independent variables (X1~X7) including age, gender, education, vocation, health condition, frequency and time of weekly exercise (Table 6). The resulting regression models can be used to express relations between levels of the motives or lack of ability and characteristics of target users. In other words, by having target users' information such as age, gender, frequency and time of weekly exercise, their level of motives and lack of ability can be estimated via the regression models.

**Table 6.** Definition of independent variables for regression models.

| Independent Variables | Description | Variable Level |
|---|---|---|
| X1 | Gender | 1: male<br>2: female |
| X2 | Age | 1: age 15–20<br>2: age 21–25<br>3: age 26–30<br>4: age 31–40 |
| | | 5: age 41–50 |
| | | 6: age 51–60 |
| | | 7: age 60 above |
| X3 | Vocation | 1: service<br>2: manufacture<br>3: office work<br>4: house keeping |
| | | 5: student |
| | | 6: retirement |
| | | 7: others |

**Table 6.** *Cont.*

| Independent Variables | Description | Variable Level |
|---|---|---|
| X4 | Education | 1: lower than junior high<br>2: senior high<br>3: college<br>4: graduate school |
| X5 | Health condition | 1: bad<br>2: all right<br>3: good<br>4: very good |
| X6 | Exercise frequency | 1: none<br>2: 1–2 times per week<br>3: 3–5 times per week<br>4: more than |
| | | 5 times per week |
| X7 | Average exercise time | 1: 0–30 min per week<br>2: 31–60 min per week<br>3: 61–90 min per week<br>4: more than 90 min per week |

Among the 15 regression models, regression models for M2, M3, M4, M6, and M7 passed the significance tests, while regression models for all five abilities (A1~A5) passed significance tests (lists of motives and abilities shown in Table 1) and the significance level is set at 0.05. To use these regression models, one can refer to Table 6 and substitute independent variable values describing target users to obtain estimates of motive and lack of ability. The following shows the significant regression models for different motives and lack of ability:

$$\begin{aligned} M2 &= 3.317 + 0.580 \times X1 - 0.183 \times X2 \\ M3 &= 4.087 + 0.167 \times X7 \\ M4 &= 3.118 + 0.154 \times X4 \\ M6 &= 2.797 + 0.139 \times X5 + 0.270 \times X7 \\ M7 &= 2.741 + 0.187 \times X5 \\ A1 &= 3.592 + 0.354 \times X1 + 0.142 \times X4 - 0.185 \times X5 \\ A2 &= 3.568 + 0.424 \times X1 \\ A3 &= 3.604 + 0.350 \times X1 \\ A4 &= 3.434 + 0.142 \times X4 \\ A5 &= 3.272 + 0.279 \times X1 + 0.146 \times X4 \end{aligned} \quad (1)$$

By observing the coefficients in these models, one can learn about positive and negative relationships between independent variables and dependent variables. For example, in the first equation, M2 denotes the motive of audio pleasure, X1 denotes gender (X1 = 1 denotes male; X1 = 2 denotes female), and X2 denotes age (see Table 6) while the other independent variables did not reach the significance level of 0.05 for *t*-test in this regression model. Once the target user is specified with characteristics like gender and age, the regression model can help estimate the level of motive M2. The positive regression coefficient for X1 and negative coefficient for X2 in the first regression model indicate that female and young people significantly prefer products offering more audio pleasure like music playing.

## 5. A Six-Step Method to Retrieve Cases and Obtain Useful Design Suggestions

In this section, a novel method for generating design concepts to persuade users to increase bodily movements is proposed based on the concepts of case-based reasoning with a case library containing 98 cases. To make case retrieval and propose suggestions easier and faster, an information system based on data management software ACCESS was written to aid the process. Product designers may

begin with identifying their design requirements through specifying target behavior, depending on which parts of body are required to be active and what kinds of behavior flavors are expected. On the other hand, if target users are specified, prior analysis could be conducted to identify their motives and lack of ability to use the new product. With specified target behavior and target users, cases matching the given attribute values can be retrieved, thereby providing past successful experiences for inspiring new designs.

Designers can refer directly to retrieved case profiles or get inspired by the design suggestions including applicable technology, design principles and design techniques that utilized in the retrieved cases. However, since the proposed approach is for generating pertinent design concepts instead of generating detail design, it is difficult to provide "verification" of the results objectively. The contribution of this work is to identify and provide design suggestions for specified target behaviors and target users with the help of a case library. When multiple cases are retrieved, the frequency of the occurrence of design principles, design techniques and applicable technologies in the retrieved cases are counted and used as a base of design suggestions. The idea is that the most frequently used ones should be recommended to designers with higher priority. Please refer to Figure 1 that shows the scheme of the proposed approach. In inspiration mode, retrieved case profiles are used to inspire designers, while in prescription mode, suggestions on design principles and techniques and applicable technologies appeared in retrieved cases are summarized and deliberately presented for stimulating new design ideas.

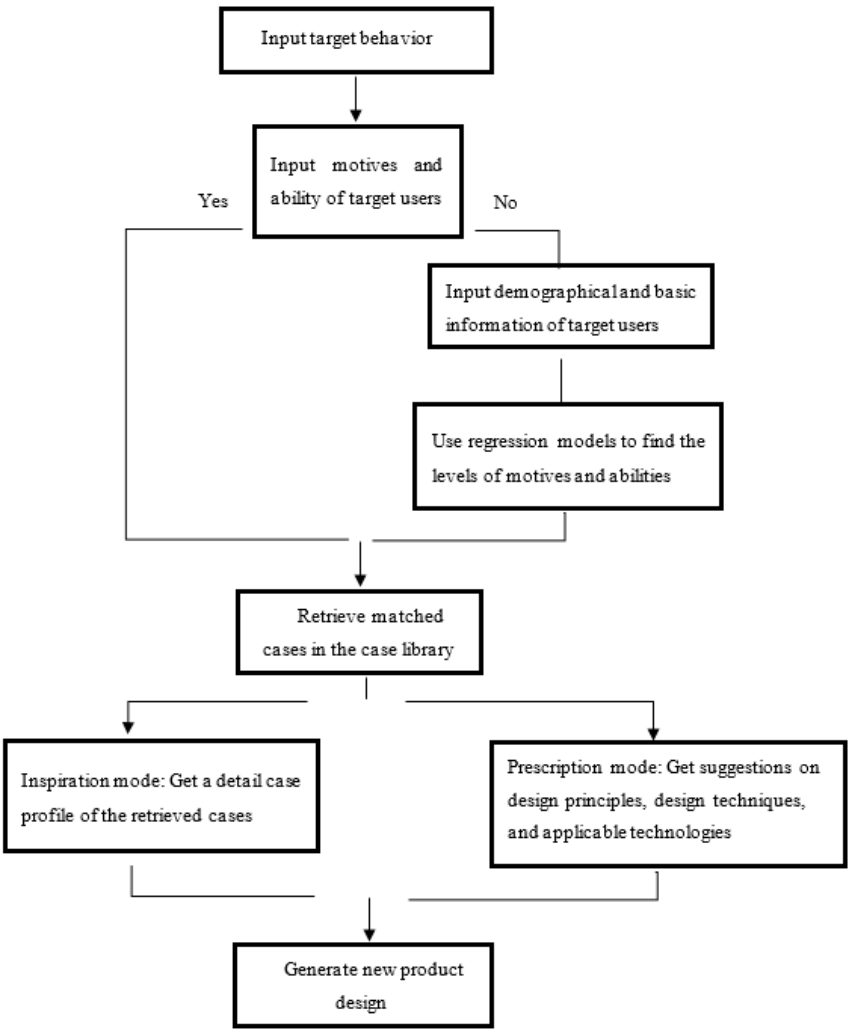


**Figure 1.** Scheme to find useful cases and design suggestions.

To summarize, a six-step procedure is proposed to use a case library to find useful suggestions on design principles, design techniques and applicable technologies. Tables 1–4 and 6 are useful while following the six-step procedure. An illustrative example is presented in next section.

(1) Specify a goal of the design project, either an existing product that needs some new idea to improve or a completely new product is expected starting from conceptual design. Refer to the nine types of target behavior in Table 1 and choose a target behavior defined by the expected part of body moving and behavior flavors.
(2) If target users are specified, conduct a prior analysis on target users to find their motives and lack of ability in performing the target behavior. A list of motives and abilities is available for consideration in Table 1. Interviewing with some users may be necessary to identify motives and ability. This study proposes regression models to help identify target user's motive and ability in advance as described in Section 4. With the responses from a questionnaire survey, 15 regression models are established with seven independent variables (X1~X7) including age, gender, education, vocation, health condition, frequency and time of weekly exercise (refer to Table 6). By inputting aforementioned variables, designers could get the estimates of users' motives and lack of ability that can be used as input conditions to search for similar cases.
(3) Use results of (1) and (2) as input conditions to search for similar cases and retrieve case profiles and indices representing design principles, techniques and technologies. These design principles, techniques and technologies used in retrieved cases serve as output of the search. Tables 2–4 contain the lists of design principles, design techniques and applicable technologies. Relax some minor conditions if no case could be retrieved and conduct a search again.
(4) One way of using the retrieved cases is called "inspiration mode", where designers simply get inspiration from retrieved case profiles that contain case description, picture, and background information in addition to design principles, design techniques and technologies. An information aid based on data management software ACCESS was written to help conduct steps (1) to (4), making case retrieval and extracting useful suggestions easier and faster.
(5) Another way of using the retrieved cases is called "prescription mode", while design principles, design techniques and technologies used in the retrieved cases are explicitly presented as design suggestions. When multiple cases are retrieved in the search, summarize the frequency of the occurrence of each design principle, technique and technology. The ones appear more frequently in the retrieved cases should be recommended with higher priority. This is a simple and logic way to highlight useful suggestions out of multiple retrieved cases. It may also be helpful to trace back how these design principles, design techniques and technologies are used in the retrieved cases.
(6) Following either the inspiration mode or the prescription mode, designers may generate and screen creative ideas of product design. For example, by following prescription mode designers could play with different combinations of recommended design principles, design techniques and applicable technologies and see if new ideas can be generated, thereby choosing a good one out of them.

It is worth noting that this work simply uses some basic concepts of case-based reasoning. In addition to "retrieving" and "reusing" the cases shown in the suggested procedure, cases can be revised and retained with the required information of the attributes so that the knowledge and cases can be accumulated for future use.

## 6. An Illustrative Example

To illustrate the proposed method, an illustrative example is presented herein. The following are the results of conducting the proposed six-step procedure facilitating a persuasive design.

(1) For illustration, suppose designers want to develop a new product to help elder women in Taiwan keep lower body moving and help them remain healthy. Target behavior will take more

lower limb movements assuming that users want to increase the intensity of familiar exercises rather than try a new exercise, leading to a target behavior in Table 1. Good examples of familiar behavior for local elders are riding bicycle and jogging.

(2) Assuming that target users are elder women who seldom exercise, detail description may include: female, age 51–60, graduated from senior high school, health condition is not good, less than one exercise session on average, and exercise time less than 30 min per week. By putting this user information as independent variables into regression models (Equation (1)), estimates of motives and lack of ability can be obtained as shown in Table 7. For illustration, assuming that the items with resulting estimates of dependent variables more than 3.5 in Table 7 are considered as significant ones, M3, and A1–A5 are considered as significantly strong motives and abilities that can be used in case searching.

**Table 7.** Estimates of motive and ability for the illustrative example.

| Estimates of Motive and Ability Using Regression Models | | | |
|---|---|---|---|
| **Motive** | **Level** | **Ability** | **Level** |
| M2: audio pleasure | 3.379 | A1: saving time | 4.214 |
| M3: physical excitement | 4.254 | A2: less physical effort | 4.416 |
| M4: learning | 3.426 | A3: less brain cycle | 4.304 |
| M6: accomplishment | 3.345 | A4: less social deviance | 3.718 |
| M7: fashion | 3.115 | A5: turning behavior to routine | 4.122 |

(3) With the information of target behavior and significant motives and abilities of target users from the above two steps, one can conduct conditional search for cases meeting the condition. Seven cases out of 98 cases are found matching the conditions and thus retrieved.

(4) In the inspiration mode, detail case profiles of the seven retrieved cases can be presented to designers for stimulating new ideas, including Wii Fit Rhythmic Game, Wii Fit Jogging, Wii Fit Snow Skiing, Piezo-electric Harvester shoe, POWER Leap Power Floor, Piezo-electric Floor in Tokyo Station, and FitWet. If designers still cannot get inspired and create new ideas from the results, they may go to the next step.

(5) In the prescription mode, design principles, design techniques and technologies used in the seven retrieved cases are summarized as shown in Table 8. The meanings of the indices of design principles, design techniques and technologies are shown in Tables 2–4 also presents occurrence times of each of them in the seven cases in descending order. The ones with more occurrence times are recommended for use with higher priority.

**Table 8.** Design principle, technique and technology appeared in retrieved cases.

| Design Principle | Appearance Times | Design Technique | Appearance Times | ICT Technology | Appearance Times |
|---|---|---|---|---|---|
| B | 7 | E4, E5 | 4 | T1 | 4 |
| A, H | 6 | H2, A3, H1, A1, D1, B9, I1, J3, K1, L4, M1, F2 | 3 | T12, T9, T8, T7, T4 | 3 |
| D, E | 4 | N2, N3, B4 | 2 | T11 | 1 |
| F, I, J, K, L, M, N, O, P | 3 | P1, D2, O1, B8, B5 | 1 | | |

(6) With the suggestions of the design principles, design techniques and applicable technologies as listed in Table 8, one may get inspiration either from each individual suggestion or from different combinations of them to obtain new design concepts. Reviewing how these design principles, design techniques and technologies are used in each of the retrieved cases may also be beneficial. To illustrate how one could be inspired by the suggestions in Table 8, samples of new product

concepts are shown in Table 9. These ideas are for illustration showing different combinations of the design principles, design techniques and technologies may inspire new product concepts.

**Table 9.** Illustrative design ideas for example purposes.

| Illustrative Ideas Inspired from Recommended Design Principles, Techniques and Technologies | | | |
|---|---|---|---|
| **Recommended design principle** | **Recommended design techniques** | **Recommended technologies** | **Ideas inspired** |
| B | B9 | T7 | let the pedal vibrate as a reminder whenever users stop cycling |
| E | E5 | T1, T4 | let users know her health conditions such as blood pressure and calories consumption by setting sensors on the pedals |
| B | B9 | T12 | turn the cycling into energy generation source that provides electricity for music playing, but music may stop once cycling stops |
| H | E4 | | let pedal generate heat in winter to keep users' feet warm |
| A | A3 | | put handy and simple control device close to users so that users do not have to bend their back for it. |
| A | D1 | | make the product portable and easily be used in kitchen, bathroom or other places so that users can do some housework at the same time as they exercise their lower limbs |

## 7. Conclusions

A case-based method is proposed to aid persuasive design for the type of products that persuades users to conduct more bodily movements, thereby leading to LOHAS. A domain knowledge model describing cause-effect relationship between design, technology and behavior change is established to help extract knowledge from past cases, thereby facilitating finding useful design suggestions. The domain knowledge model consists of five groups of attributes including target behavior, design principle, design technique, applicable technology, and user's motive and ability. Users' motives and ability are deliberately included in the domain knowledge model to enhance the explanatory power of the model, especially when target users are specified. A case library that includes more than 98 cases containing experiences of persuasive design is constructed so that cases matching given conditions can be retrieved for design suggestions.

A six-step procedure is recommended for step by step execution with the established case library. Conditional search is conducted where target behavior, target user's motives and ability are input conditions and cases meeting these conditions are retrieved for inspiring new ideas. Target users' motives and lack of ability can be identified by using regression models resulted from a questionnaire survey where seven independent variables are defined to represent target users' characteristics. Designers can either get inspiration directly from retrieved case profiles or bring about new design concepts based on the recommended design principles, design techniques and applicable technologies. When there are multiple retrieved cases, frequently used design principles, techniques and technologies are recommended with priority. A computer program based on ACCESS is written to promptly conduct the conditional search, retrieve useful cases and highlight useful design principles and applicable technologies for facilitating persuasive design. An illustrative example is presented at the end, demonstrating the application potential of the proposed method.

**Acknowledgments:** Author would like to thank Ministry of Science and Technology of Taiwan for the financial support (MOST 103-2621-M-006-002). Author also appreciate the work of Wan-sin He and Chieh-ju Sun as research assistants in this project.

**Conflicts of Interest:** The author declare no conflict of interest.

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