

Incorporating Virtual Forms into Traditional Things to Increase Their Values

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Abstract. Computing technologies allow us to enhance our daily objects by adding virtual forms to the objects. The virtual forms present dynamically generated visual images containing information that influences a user's behavior and thinking. In a typical way, adding a display to show visual expressions or projecting some information on an object offers visual forms on the existing daily objects. We have designed three case studies that add virtual forms to existing objects. The first case study is Virtual Aquarium, which offers a virtual aquarium that reflects a user's toothbrushing behavior. The second case study is Augmented Go, which projects additional information on the real Go board for making a better decision in the game play. The third case study is Augmented Trading Card Game, which adds virtual characters and special effects on the trading cards of the Nintendo DS game in order to encourage and provoke more social play of the game.

In this paper, after presenting an overview of the three case studies that enhance traditional objects with virtual forms, we present six values that play an important role in the design of the enhanced objects. We believe that these values would be useful in the design of any other enhanced objects with virtual forms.

Keywords: Virtual forms, Augmented reality, Values, Gamification.

1 Introduction

Recently, daily digital objects are becoming more and more usual and widely sold commodities. For example, recently televisions developed in Japan have become cheaper and cheaper despite of their excellent product quality and rich functionality. Also, Android mobile phones are becoming popular and a wide range of models and functionalities is offered on the market. However, it is very difficult for the users to distinguish the differences in the phones and make a choice. The fact that the product quality does not become the value for many of us to buy the product shows that we need to consider another way to design daily digital objects. However, we found that new furniture and fashion goods attract us every year and they do not become commodities that are sold at cheaper prices with the time. The reason for this is the fact that they offer additional values to users. Especially, the prices for such products are kept high if the products offer the sense of rarity. Digital technologies are effective to make digital objects a usual commodity and as a consequence to make their prices cheaper, but these technologies are also effective to add more values to the products

by customizing them for each user [5]. The customization may offer the objects more attractiveness, which might lead to the increase in their prices.

Virtual forms are realized by adding displays and by projecting information on the objects, and can be changed dynamically according to the current surrounding situation. This approach is promising to enhance daily objects, and offer more values on the objects. We have designed three case studies to augment existing objects with virtual forms. The first case study is Virtual Aquarium, which offers a virtual aquarium that reflects a user's toothbrushing behavior. The second case study is Augmented Go, which projects additional information on the real Go board for making a better decision in the game play. The third case study is Augmented Trading Card Game, which adds virtual characters and special effects on the trading cards in the Nintendo DS game to encourage more social play of the game.

From the experiences with the design of the case studies, we have found six values to consider how to offer additional values in the enhanced objects with visual forms. The values can be used in the following steps. The first step is to identify the values in the traditional objects. Then, they can be used for discussing which values should be added or changed in the enhanced objects in order to increase their values. Finally, we consider what kinds of virtual forms can be suitable for making the objects richer and more enjoyable.

In this paper, we present a brief overview of the three case studies and identify the extracted values from these case studies. It is a future issue of our research how to use the values to design enhanced daily objects. In the future, we also consider the possibility to use these values in order to gamify various activities.

2 Three Case Studies

2.1 Virtual Aquarium

Virtual Aquarium is an object called a persuasive mirror [6] that has been developed and has the objective of improving users' dental hygiene by promoting correct toothbrushing habits. It is set up in the lavatory where it turns a mirror into a simulated aquarium as shown in Figure 1. Fish living in the aquarium are affected by the users' toothbrushing activity. If users brush their teeth properly, the fish prosper and procreate. If not, the fish become unhealthy and may even perish.

In *Virtual Aquarium*, we use a 3-axis accelerometer sensor that is attached to each toothbrush in a household. A user brushes his teeth in front of *Virtual Aquarium* using a brush with a sensor attached. Since toothbrushes are usually not shared and each sensor has a unique identification number, we are able to infer which user is using the object at a given time. Toothbrushing patterns are recognized by analyzing the acceleration data. The toothbrush is able to observe how the user brushes his/her teeth passively. This is the only interaction needed to use this object.

In this case, the ideal user's behavior model is defined as follows: 1) a user brushes his/her teeth at least twice a day; 2) one session involves at least three minutes of brushing; and 3) brushing involves patterns that ensure the teeth are properly cleaned. Each user's behavior is compared to the ideal one and translated into a feedback as described below. We believe that the existence of an aquarium in the lavatory is not disturbing and unnatural, but improves our daily life.

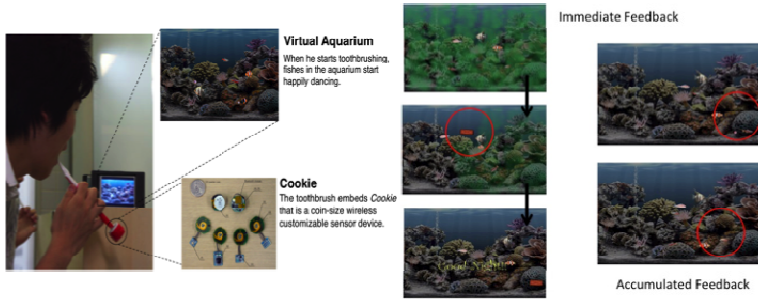


Fig. 1. Virtual Aquarium System

As shown in Figure 1, when a user begins to brush his/her teeth, a scrub inside the aquarium starts cleaning the algae off the aquarium's wall. At the same time, a set of fish associated with the user starts moving in the aquarium in a playful manner. When the user has brushed his/her teeth for a sufficient period of time, the scrub finishes cleaning and the fishes' dance becomes even more elegant. When the user finishes brushing, the fish end their dance and resume their normal activities. Both the activities of the fish and the movement of the scrub are designed in such a way as to give the user hints regarding the correct method of toothbrushing. However, if a user does not brush his/her teeth sufficiently, the aquarium becomes dirty, and the fish in the aquarium become sick. The feedback information is returned immediately according to the movement of the user's toothbrush. We call this feedback *immediate feedback*.

The health of the fish is visibly affected by how clean the aquarium is. If the user neglects to brush his/her teeth properly, fish health worsens. In contrast, faithful brushing may result in the fish laying eggs as shown in the right pictures of Figure 1. At first, the eggs are not very likely to hatch. If the user continues to brush consistently for a number of days in a row, the incubation ratio increases. This way, the long-term feedback gives clues to the correct behavior and attempts to maintain motivation over a period of time. The long-term feedback is called *accumulated feedback*.

While designing the object, we consider the association between a user's healthy lifestyle and the cleanness of the aquarium. Our design takes into account the fact that the user feels empathy for the virtual fish.

In our daily life, a mirror reflects our figure to show our appearance. The mirror allows us to know whether we are well or not, whether our makeup and clothes fit or not and so on, and has the power to make what is invisible from us visible. We believe that mirrors are adequate devices to reflect our current behavior that return immediate feedback on the current situation. *Virtual Aquarium* is a new type of mirror that reflects a user's current state, encourages him/her to change his/her behavior and motivates desirable lifestyle.

2.2 Augmented Go

Go is a traditional board game for two players, where the goal is to occupy a larger portion on the board than the other player. Black and white stones are used to control the territory and a board with a grid of 19 x 19 lines is used as the game field. The rules of Go are relatively simple, but the underlying strategies are extremely complex

and rich. As in chess and reversi, a numerous set of strategies have been invented to reduce the complexity, but studying them requires the player to actually understand the strategic concepts. Thus, it takes a long time for a beginner to play well with an experienced player and to feel pleasure during the play. *Augmented Go* [9] supports several gaming modes to play a game. The basic idea is to offer useful information to beginners without extra interactions and intrusive devices as shown in Figure 2. A virtual form in Augmented Go is superimposed onto the real Go board. Proactive feedback information is offered visually by superimposing guidance information onto the Go board by a projector. A web camera connected to a personal computer is used to detect the position of each Go stone. The OpenCV library is used for visual analysis and the core logic of the enhanced object generates information presented to the players according to the current game situation.

The system supports several gaming modes. As shown in Figure 2-(a), players can interact with the object by placing Go stones on a menu that is projected onto a board. We explain some of the modes and how players interact with *Augmented Go*.

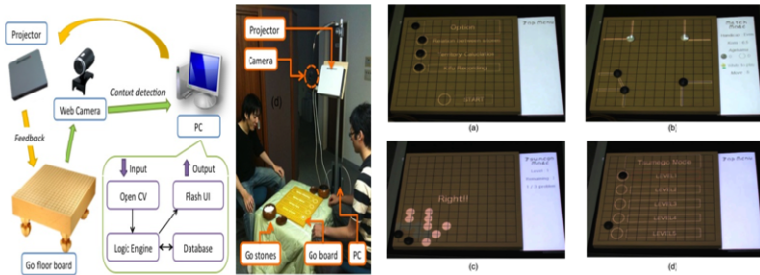


Fig. 2. Augmented Go System

Normal Play Mode: The normal play mode is the basic form of the Go augmentation. In this mode, two players play Go as usual, but useful information is projected on the board to help beginners recognize the situation and make better decisions. The rules of Go are simple, but the vast number of possible moves in each turn makes it hard for beginners to make decisions. Moreover, on the large 19x19 board, beginners tend to concentrate on localized fighting in a narrow region and lose the big picture. It is difficult to recognize invaded areas, since an invasion process gradually progresses as new stones are put on the board. For choosing good offense and defense strategies, recognizing the links between the Go stones is important, but it requires some skills. Moreover, the normal play mode visualizes the strength of links between the Go stones. As shown in Figure 2-(b), same-colored stones are connected with lines. If a dangerous situation occurs somewhere on the board, a warning message appears for the players to avoid losing the area. The sequence of stone moves is also recorded into the database, which facilitates replaying the game for self-training. Replaying allows us to review and analyze the play by projecting the stones on the board later.

Tsumego Mode: Tsumego is a type of exercise where the player is given a game board situation. The aim is to find the best sequence of stones' placement in a given board situation. In this mode, the positions of the stones are visualized on the board.

Players can try different moves by placing stones on the board, with the results and comments explaining key important points displayed as visual feedback (Figure 2-(c)). The Tsumego mode prepares questions for a player with different skill levels, and the level of difficulty can be selected in the menu.(Figure 2-(d)).

The advantage of our approach is to allow players to receive information through the normal interaction with the Go board and the stones. By superimposing information onto the board, players can concentrate on the normal play or self-training without fragmenting their attention by taking an instructional book and etc. into their hands. This is important to make it possible for the players to allocate enough cognitive resources for understanding the current situations in the game.

2.3 Augmented Trading Card Game

A trading card game is also commonly referred to as a collectible card game, a customizable card game, or CCG. For our purposes here, we will use trading card game (TCG) to refer to all the three varieties of games. In a nutshell, a TCG combines the collectability of trading cards with strategic game play. Typically a player purchases a starter set, containing a playable deck of cards and a manual that includes an explanation of the rules and the mechanics of the game in an introductory fashion. One of the biggest problems faced by any new TCG player is the need for an opponent to truly engage in the game play, as it is extremely unusual for any TCG to feature a solitaire mode. Players usually begin playing with a friend, at a particular location such as a hobby game store that offers organized gaming opportunities and includes a tutorial component, or via an online portal.

Computer-based TCG is also becoming popular, and in our project we make a comparison between the real TCG, and its virtual one running on Nintendo DS¹. An important conclusion resulting from that comparison is that the computer-based TCG loses a lot of realities offered by the real TCG [7]. For example, the sense of real cards is essential for many TCG players since making and completing collections of cards is a significant fount of pleasure for them. The computer-based TCG also implies some communication limitations, because it allows a player neither to have an eye-to-eye contact, nor to look at or chat with the opponent player.

As described above, although most of the current computer-based TCGs lose the realities of the real TCG, we claim that ubiquitous computing technologies may help to recover these lost realities and encourage and attract players to enjoy the computer-based TCG in a very similar way to the real TCG. Moreover, adding special effects and virtual forms to the computer-based game might increase the excitement of the game even more than the real one.

Figure 3 shows Augmented Trading Card Game that is currently developed in our project. The system extends the trading card game running on Nintendo DS, where two players are usually located in different places while playing the game. In Augmented TCG, the opponent player is represented as a virtual character that is visualized using a tool called MikuMikuDance. The movement of the character is synchronized with the movement of the real opponent player by using MS Kinect, and

¹ In the paper, real TCG means that the game is performed using real trading cards on a real table, and two or four players play the game face-to-face.

the behavior of the character is determined by the information retrieved from a biosensor attached to the opponent player, i.e. the virtual character's behavior and emotions reflect the real player's behavior to some extent. In Augmented TCG, two virtual forms are used. The first form is superimposed onto the playing table to show the virtual trading cards and some special effects during the play. The second virtual form is installed on the wall to show a virtual character.

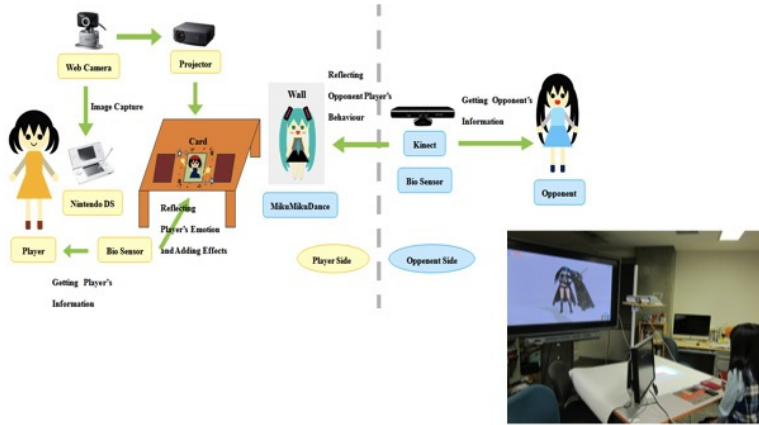


Fig. 3. Augmented Trading Card Game

The trading card itself is also enhanced in the system. Cards presented on the display of the Nintendo DS are retrieved by Web cameras and projected on a real table. The projected cards can be enhanced by adding special battle effects or empathetic effects to the characters shown on the cards.

In the original computer-based game, a player usually cannot see the opponent player. The proposed Augmented TCG enables us to recover this lost reality by adding a virtual character whose movement and behavior are synchronized with the movement and behavior of the real opponent. In addition, the virtual trading cards carry some special effects that increase the sense and the excitement of the battle. Similarly, if the character drawn on a trading card shows some empathic expressions, a player feels empathy with the character on the card, and feels more enthusiastic and committed to the game. These special effects compensate the lost realities of the real trading cards. Also, virtually attached rarity to the virtual trading cards brings a feeling of reality and encourages a strong will to collect virtual trading cards.

3 Design Implications

Baudrillard proposed that the consumption becomes more symbolized and additional values become more important than the products as materials [1]. For example, a brand offers significant additional values to fashion items, and a consumer feels the value on their virtual properties. On the other hand, adding values to virtual items

makes a user feel the items materialized. This means that real products are becoming more virtual, and virtual products are becoming more real.

From our experience with the case studies, we extract six values to be used in the design of virtual forms that augment traditional objects. The first value is the physical value that offers the tangibility to the objects. During the design of Augmented TCG, we compare the traditional trading card game and the game running on Nintendo DS. The comparison shows that many players prefer the feeling of the tangibility of the real trading cards while playing the game [7]. We believe that this value increases the reality when some objects exist in the virtual world [3]. The second value is the empathetic value. In Augmented TCG, the usage of this value in the virtual character increases the friendship with the opponent character when the player likes the character. The third value is the persuasive value that offers extrinsic motivation to a user. The transtheoretical model [8] defines five stages to change a user's behavior. This value is used in Virtual Aquarium, where a user continues to brush his/her teeth making fish in the aquarium healthy. Then, in the later stage, the cleanness of the aquarium is a metaphor of the cleanness of the user's teeth, and the metaphor is useful in order to make the user aware of the importance of toothbrushing. The fourth value is the informative value. The value is effective to make a better decision. In Augmented Go, some information that helps the player to choose the position of the next Go stone is projected on the real Go board. The next value is the economic value. The value is not directly used in the current case studies, but we discuss the importance of the value when designing the case studies. For example, a player might like to buy special effects in Augmented TCG in order to improve the play or increase the excitement of the game. Finally, the last value is the ideological value. The value represents the metaphor that shows the dream or expectation of a user.

The described values are useful to identify what the main values of the traditional objects are and how to add additional values to the objects for making the objects richer and more enjoyable. For example, in Augmented TCG, we found that the original game running on Nintendo DS has some problems. For example, since the player does not see the opponent player, he/she tends to easily cheat in the game. We believe that using the empathetic value to the virtual character of the opponent player will prevent from cheating in the game. Moreover, adding special effects to the trading cards are useful to motivate the players to win the game fairly.

During the discussion of the case studies' development, we consider the importance of the economic value. We consider that incorporating virtual items to be exchanged among users is a promising way to motivate users to use the enhanced object [4]. For example, if a user develops a new way of customization of an object, the other users might be interested to use the customization even if they need to pay some money for it. We believe that this kind of customization may offer an attractive business model to objects.

Aesthetics is an important concept to design the ideological value. Especially, in Japan, incorporating the ideological value in Japanese products is a promising way to sustain Japanese Economy [2]. Japanese traditional folkcraft represents the aesthetic value, and we need to investigate how to incorporate the aesthetic value into digitally enhanced objects.

4 Conclusion

The paper shows three case studies that add visual forms to enhance daily objects. From our experience with the design of the case studies, we extract six values that would be useful for the design of the future digitally enhanced objects.

Our approach to add virtual forms to existing objects makes it possible to gamify the use of the objects and make it more enjoyable. Gamification [10] recently becomes a popular way to make daily and business activities more attractive. We hope that the proposed values would be helpful for the successful gamification of these human activities.

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