Sustainable Relationship with Product by Implementing Intentional Interaction

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ABSTRACT
Interaction between a user and a product like a home-appliance is sometimes a mutual relationship. A product not only provides service to a user, but also requires maintenance by the user to keep it working smoothly. If the user stops paying attention to maintenance, the product will no longer be used. To keep a sustainable relationship between a user and a product, the author proposes making a product an agent with anthropomorphic representation and interaction supported by the Anti-max Prisoner's Dilemma game.

Categories and Subject Descriptors
H.5.m [**Information interfaces and presentation**]: Miscellaneous

Keywords: Human-agent interaction, human interface, genetic programming

1. INTRODUCTION
Modern life is supported by many kinds of products. Some products keep their ability by the support of users. For example, a refrigerator provides the user with food within a given temperature range, but to keep it working, food needs to be supplied by a user. An office printer requires paper and ink to sustain printing. If a user loses motivation to use a product and stops maintaining it, the product will no longer be used. What is required for sustainable use of a product?

Donald Norman, a famous product designer, noted in his book that the usefulness of a product is not the main factor for continuous use [1]. He illustrates this by showing how the design of several products has not simply a useful but also an emotional dimension. He emphasizes that this emotionality stimulates a user's motivation.

One case of the use of emotion is a method in which a product functions as an agent. If a product is cognitively recognized as an agent by a user, the user becomes more motivated to use it. A pet robot is an example of how anthropomorphic appearance provides motivation [2]. The results of several studies demonstrate that making products function as agents give successful results. For example, Osawa et al. found that older people were motivated to learn when the appearance of a product is anthropomorphized and explained its function by itself interactively [3]. Owada et al. demonstrate continuous use of home-appliances by representing home-appliances as virtual agents and showing the relationship between products as a drama for maintaining intention with a product [4].

While these findings show the advantages of agency in a product, implementing intelligent interaction between a user and an agent is difficult. In the case of Osawa et al., each explanatory content is running on a fixed protocol and is not intelligent. In Owada et al.'s method, contents (including graphics and voices) are provided by a company sequentially. However, doing this is very costly.

To find a way to motivate the users to give their attention to a product with a small effort, the author proposes decorating the interaction between a user and a product with a minimized intentional game based on game theory. A product shows its own emotion during interaction (maintenance and use of the product) and makes an interaction as a reward trading game described in a 2 x 2-reward table. Thus, a user is required to read the agent's intention. This factor accelerates anthropomorphic attitude of a user toward a product. The author used the Anti-Max Prisoner's Dilemma (AMPD) game proposed by Angeline as a reward table. In this game, the average reward of both players is maximized when each player defects alternately. It requires mutual trust. The author found that AMPD game generates a complex internal state of an agent, and each agent behaves as if it has an intelligent intention that tries to outsmart the other side [5]. The strategy of the agent is described by an automaton, which is automatically generated by computer simulation.

2. DESIGN OF AGENCY
2.1 Anthropomorphic Devices
To give a product an agent-like appearance, we used eye-like devices proposed by the Morphing Agency [6]. Each eyelike device has a movable eye-display controlled by a motor, and makes the product appear to be an agent in accordance with the context. The device has its own battery and it is wirelessly controlled by computer via Bluetooth. Thus, this device is attachable to any surface of a product.

The author focused on the refrigerator as a first example to evaluate our method. The examples of interaction are shown in Fig. 1. The refrigerator requires continuous maintenance for providing cooled foods (a user supplies food). The refrigerator is a good showcase to evaluate well how our method can make sustainable relationships between a user and a product.

The author used Leap motion sensor and bend sensor for detecting when food is put on take out foods. The Leap motion sensor is set on the below side of the refrigerator, counts hand motions, and detects whether the food is provided or stored. The bend sensor

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detect whether the door is open or closed. The eyes on the products opens after user's action, and shows selected emotions in accordance with its internal strategy.

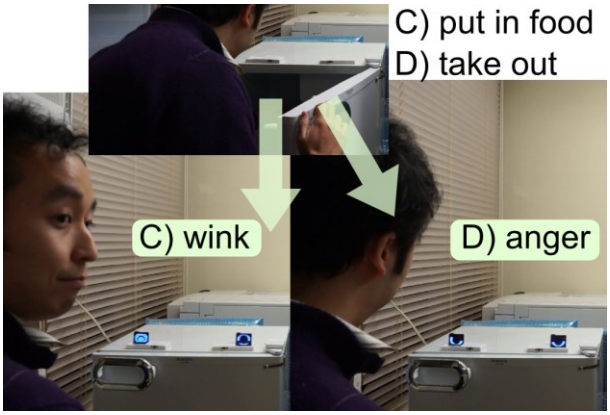

Figure 1. Interaction between user and anthropomorphized refrigerator

2.2 Anthropomorphic Interaction Protocol

We designed interaction between a user and a product as a trading game shown by 2 x 2- reward table. A payoff table of a trading game between a user and a product is shown in Table 1. The AMPD payoff scheme is shown in Eq. 1.

Table 1. Payoff table of Anthropomorphized Product.

		Product	
		Wink (cooperate)	**Anger (defect)**
User	**Maintenance, put in food (cooperate)**	$(U:c, P:c)$	$(U:b, P:a)$
	Use, take out (defect)	$(U:a, P:b)$	$(U:d, P:d)$

$$a > c > d > b, \quad a + b > 2c \quad (1)$$

First, the system categorizes the user's behavior into two patterns as shown in Table 1. Maintenance, or putting in food, means cooperative behavior to the refrigerator. Using or taking out food means defective behavior for the refrigerator. Second, the agent has two behaviors as shown in Fig. 2. In cooperative behavior, the eye-like devices wink at the user and suggest a cooperative attitude to the user. In defect behavior, the devices show a sleeping face to a user, which suggests it is not cooperative.

We estimated a payoff table for AMPD as a = 3, b = -2, c = 0, d = -1 based on above estimation and previous studies by Angeline and Osawa et al. These parameters include both physical and cognitive load and rewards. If a user is cooperative towards the refrigerator while the refrigerator is not, the user just exerts his/her power on a labor (-2) and the refrigerator get a reward (+3). If a user gets a food and the product winks, the user gets a reward (+3) and the product pays labor for showing wink (-2). If a user puts food in and the refrigerator winks, both rewards are averaged as 0. If a user just takes out a good and the refrigerator is not cooperative, both get minus rewards (-1).

The author generated finite state automaton of the agent by computer simulation. In the simulation, 50 agents are improved by genetic programming method, and we selected the top score automaton after 150 generations as a strategy for the refrigerator.

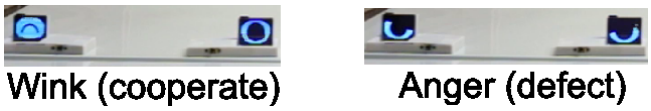

Figure 2. Two expressions (wink and anger) of attachable eyes

2.3 Preliminary Evaluation

Five participants interacted the refrigerator with the generated faces in the strategy, and the other five, the control group, interacted with a random strategy as a comparison. In this strategy every next hand is randomly selected. Each participant was instructed that he/she can stop the interaction with the refrigerator when he/she tires of it. The experimenter counted the number of interactions for each participant. The average score of interaction in the experimental group was 12.3 and the average score of the control group was 8.9. However, there is no significant difference in scores because of small participants.

3. DISCUSSION AND CONCLUSION

The study is in the initial phase. Our result is not conclusive and more evaluation is required for applying statistical analysis. We want to evaluate other products and good metaphor to verify whether the parameters in the reward table are valid. We also want to compare other well-known strategies in game theory, such as TFT and Pavlov, and evaluate what kind of internal strategy is appropriate for making a sustainable relationship between a user and a product.

4. ACKNOWLEDGMENTS

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