Services, Appearances and Psychological Factors in Intelligent Home Service Robots

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Abstract. This study conducted a questionnaire survey to investigate the requirements and preferences toward the services and appearance of home service robot. And the psychological factors regarding human robot interaction, including likability, sincerity, trust and privacy were explored and discussed. The preliminary results show that functions of house chores, security and emergency detecting were highly expected and preferred by 267 participants. While the social and caretaking/nursing functions were not preferred as expected. The participants liked medium size robots without too many facial features. Hands and arms that extended human reach were more valued than legs and wheels that substitute human movement. Participants also valued the interface of response and information, such as the body screen on the robot. Psychological factors of likability, sincerity, trust and privacy correlated with each other significantly, and were also related to the preference of robot appearance. This study takes a clear profile of the users' expectation on future home intelligent service robots.

Keywords: Intelligent service robot · Human-robot interaction · Home service robot

1 Introduction

The rapid development of robots has not only speed up the implementations in industries but also in our daily life environment. Features of autonomous systems intelligence, social systems intelligence and augmentation of human beings have gained much attention in the design and development of intelligent service robot [1, 2]. However, technological use and affordance today have changed and transformed in a significant way, and the perspective toward the intelligent service robots in home environment are different. Therefore, this study aims to investigate users' attitude towards the home intelligent service robots, including the services, outfits and the psychological factors in human robot interaction. And the necessary requirements of home service robots are constructed. Through the multidimensional investigation, users' needs and the relationship of HRI factors with the robots appearance are discovered for designing attractive and trustable robots.

2   Research Design

The survey plans to figure the attitudes and expectations toward home ISRs in services, appearances, and human robot interactions (HRIs). Questionnaire was designed into 6 parts according to the three aspects of expectations and one portion of personal information. Part 1 was the personal information. It included the surveyors' nationality, age, gender, major, and buying behavior. In the buying behavior, we investigated their buying tendency (how long would you buy new products after they had been sold), having any home ISR and the satisfaction about it, and the willingness to own any home ISR in the future. While users' background and direct using experiences might affect their attitude toward intelligent service robots, indirect experiences such as users' buying intensions and use of homogeneous products may also affect their perspectives toward home service robots. The second part of the survey investigated the requirement about the services carried out by intelligent service robots at home. Six-points scale was used to evaluate 18 services in each. The higher score was the higher requirement for that service, and participants' perceived importance of each function was collected and analyzed.

The third part of the survey investigated the style traits, body structures, and size about the appearance of intelligent service robots. In style traits, 8 questions of semantic differential scale were used to collect participants' opinions about how the intelligent service robots should look like. The participants also expressed how comfortable they would feel toward different types of service robots with a seven-points scale. Six kinds of body structures were asked through two alternative responses method. In each question, participants chose one kind of structures they liked. Finally, they were asked to circle the favorite size of robots.

The survey also collected participants' opinions of human robot interaction, likability, sincerity, and trust and privacy in specific. Six points scale was used to evaluate the degree of agreeableness. The higher score was the higher agreeableness. Likability is a positive emotion toward a personal attractive trait. In order to figure out how the robot should be in their attractiveness, the scale we used was modified from Rau's in 2009 [3]. The calculated Cronbach's α for likability in our study is 0.88. Sincerity represents the true heart in a human interaction. We developed 11 questions in the sincerity factor and Cronbach's α is 0.90. The trust and privacy was evaluated whether the robot was believable and trustworthy. The scale also referred from Rau's report [3]. In this study, the Cronbach's α for trust and privacy is 0.86. The more likability, the more sincerity and trustee would be assessed. The three HRI components should highly correlate to each other.

The final part of the survey investigated participants' acceptance toward the intelligent service robots in the future. We asked the participants to prioritize their preferences among entertainment robots, assistant/servant robots, social companion robots, caretakers/nurse robots, labor service robots, safety/security robots, information providing robots and remotely accessed robots. We also asked how much money would you spend on purchasing robots and when will you purchase it. One open question was addressed to describe the other ideas about home intelligent service robots.

3   Preliminary Findings

By ruling out the missing responses, 267 valid responses were used for further analysis. The following session reported the preliminary findings including the descriptive statistics of participants' preferences of intelligent service robots, and the relationship between participants' features and their attitudes toward the service robots.

3.1   Participants' Expectation Toward the Services of Home Robots

Among the 267 participants, 54 % were females and 46 % were males. And their ages ranged from 18 to 35 years old. The portions of age under 18 was 17 %, 19 to 25 was 79 % and 26 to 35 was 3 %. Most of the participants did not have any home intelligent service robots (98 %). The buying tendency for new products, 20 % would buy them after they sold in several months, 65 % was after one year and 15 % was above 2 years. When we asked the willingness to own any home service robots, 57 % said they will and 36 % were not sure.

The services which were thought as needed for a home service robot, with the average score above 5, were house chore related function, security function and detecting emergency phenomenon such as earthquake and typhoon. The social factors such as companion, chatting, interpersonal communication and connections were evaluated somewhat not necessary with the average around 3. The details of the service assessment were shown as Fig. 1.
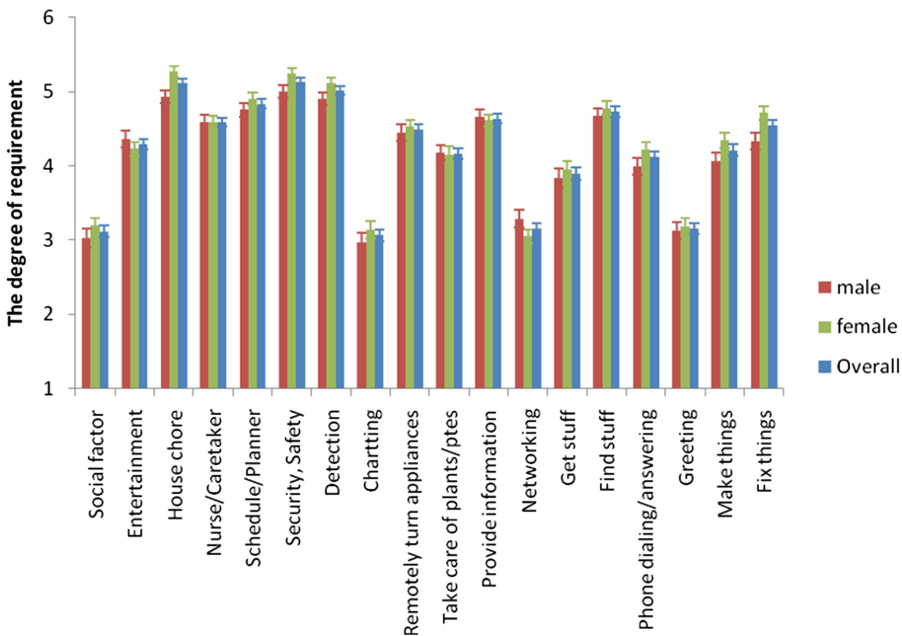

Fig. 1. Participants' requirements of services provided by home ISRs (Color figure online)

The general pattern of requirements in each service was the same between overall data and each gender. However, there were some different opinions between male and female participants regarding home assistance tasks. As shown in Fig. 1, it was found that female participants emphasized more on house chore (t(265) = − 2.86, p <.01), security/safety (t(265) = − 2.30, p < .05) and fix things (t(265) = − 2.60, p < .01) than male participants.

One way ANOVA was conducted to compare the three buying tendencies: buying new products in several months, after one year and above two years. Once the ANOVA was significant, LSD was used for post hoc analysis. We only found significant difference in fix things service (F (2,264) = 4.52, $p < .05$). Post hoc showed the average score of buying after one year was significant higher than above two years ($p < .05$).

3.2   Participants' Preferences of the Robot Appearance and Body Feature

For the appearance of the home service robots, the participants were more comfortable in associating home ISRs with futuristic, machine-like, simple, female figure, brighter color, light weighted, organic and low character. However, the average scores we got were all closing to the middle score 4. Only exception was the color trait. It must be bright not dark (Fig. 2).

For the body structures of the home service robots, chi-square analysis was conducted to examine the proportion differences in each item related to body structure. And the results suggested significant preferences on fingers instead of palms
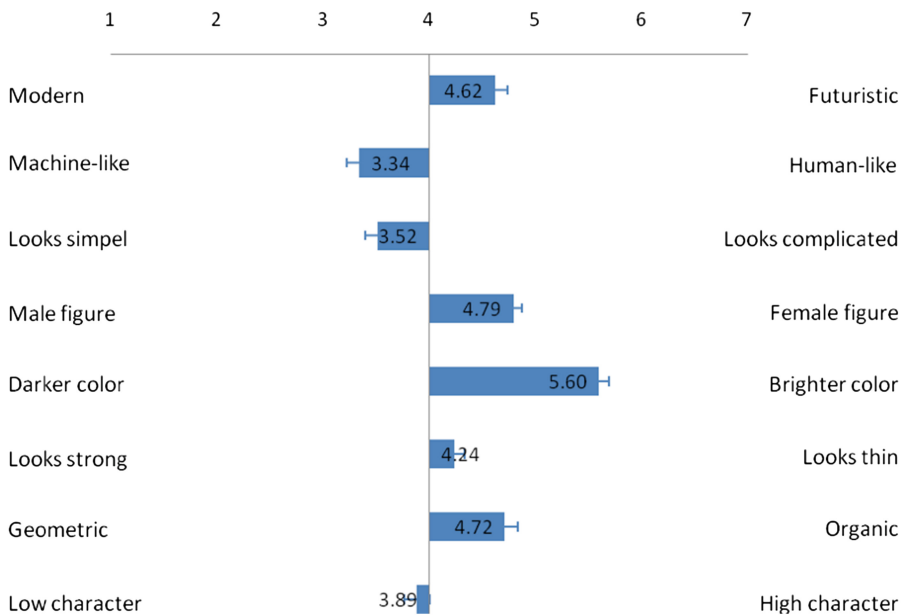

	1	2	3	4	5	6	7	
Modern				4.62				Futuristic
Machine-like			3.34					Human-like
Looks simpel			3.52					Looks complicated
Male figure				4.79				Female figure
Darker color					5.60			Brighter color
Looks strong				4.24				Looks thin
Geometric				4.72				Organic
Low character			3.89					High character

Fig. 2. Participants' expectations of the style traits of the home ISRs

($\chi2 = 78.75$, p < .01), and on less facial features ($\chi2 = 29.67$, p < .01) with abstract instead of concrete faces ($\chi2 = 21.07$, p < .01). Also the participants expected the home service robots to have arms ($\chi2 = 228.50$, p < .01) and a body screen in the front ($\chi2 = 117.34$, p <.01). Generally the participants liked home service robots to have finger (77.15 %), no facial feature (66.67 %), virtual face (64.04 %), arm (96.25 %) and body screen (83.15 %). And they preferred home service robots of medium size ($\chi2 = 262.39$, p < .01). Other body features including wheels (54.68 %) or feet (45.32 %) was not significantly different ($\chi2 = 2.341$, p = .13) (Fig. 3).
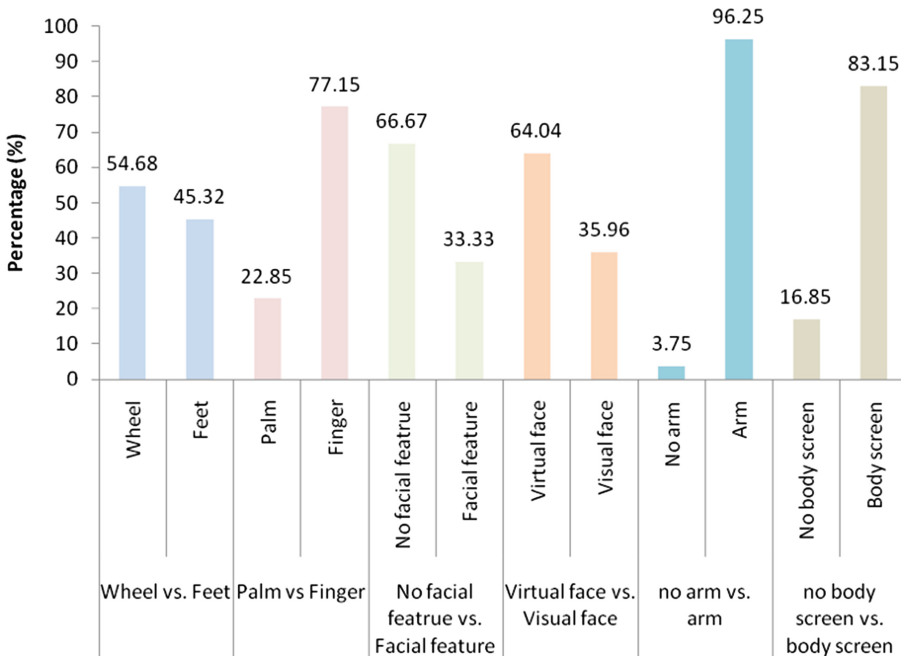

Fig. 3. Participants' expectations toward the body structures of home ISRs

Additionally, male participants showed significantly stronger preferences over the features like futuristic (t(265) = 2.53, p < .05), female figure (t(265) = 2.17, p < .05) and organic (t(265) = 5.03, p < .01). Female participants, on the other hand, liked the home service robots of more machine-like (t(265) = 3.77, p < .01), simple looks (t (265) = 5.01, p < .01), and brighter color (t(265) = − 3.10, p < .01). The tendency in choosing the body structures was similar among male and female participants. But based on further comparison by chi square analysis, female participants significantly preferred robots without facial features (74.31 %; $\chi^2 = 8.21$, $p < .01$), and of abstract virtual faces (70.38 %$\chi^2 = 5.04$, $p < .05$) more than males (57.72 %; 56.91 %).

3.3   Participants' Perceived Importance of the HRI Factors

A correlation analysis was conducted on the three HRI dimensions. The results suggested that the participants viewed the trust and privacy (5.01/6) as the most important aspects for them to interact with home service robots, followed by the likability (4.65/6) of the robot, and the last issue is the sincerity of the robot. It was also found that the likability of robots possibly affected the trustworthy to robots in interaction, and vice versa (Table 1).

Table 1. Analysis of Correlation between Likability, Sincerity, Trust and Privacy

HRI factors	Mean	SD	Likability	Sincerity	Trust and Privacy
Likability	4.65	0.77	1.00		
Sincerity	4.42	0.85	0.69**	1.00	
Trust and Privacy	5.01	0.72	0.70**	0.66**	1.00

** Result is significant at 0.01 level (2-tailed)

Echoing the perceived importance reported by the participants, the comparison of participants of different buying tendency also found that those who tended to buy things later in one year, viewed sincerity as the least important for home service robots, their scores were significantly lower than the participants who bought things in several months, and those who bought in more than two years ($p < .05$).

3.4   Participants' Preference of the Robot Types

Among the eight major types of robots, most participants thought the most popular robot was labor service robot in the future. The second was the safety/security robot. The following sequence was remotely accessed robot, assistant/servant robot, information providing robot, caretakers/nurse robot, and entertainment robot. The last one was social companion robot. The participants estimated time to have a robot at home is within 10 years (43 %). And the average price they would afford was 175,292 NT dollars (about $5,200), which equaled to the costs of 4 refrigerators or 2 motorbikes. The results reflected the participants' stereotypes of expensive robots (Fig. 4).
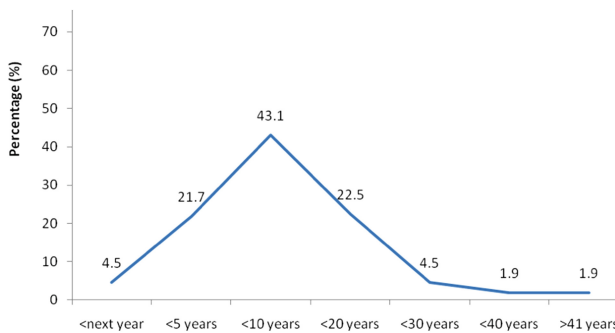

Fig. 4. Participants' estimated time to purchase a home ISR

4 Discussion and Conclusion

These results showed that the services of home ISRs were preferred in the order of house chore related function, security function and detecting emergency function. If designing involved gender preferences, the house chore, security/safety and fix things functions would be more important for female users. By comparing the participants of different buying tendencies, it was found that late buyers (after one year) valued the practical function, such as fixing things, of the home service robots. While the results of this study suggested that the local requirements of service robot in Taiwan were similar to the worldwide societies [4–7], the participants in this study emphasized the practical functions than the previous studies. Our participants expected the home ISRs to provide services in labor, secure, servant or information providing dimensions first. And viewed the social functions and features, such as caretaking and nursing as least necessary.

For the outlooks of the home ISRs, the results suggested a preferable robot of a human-like physical structure, but without an actual face and face features. Abstract representation of virtual faces is more acceptable among all participants, and specifically valued by female participants. The limbs of robots must have arms and hands for reaching out. Mobility was regarded as necessary for home ISRs, but it did not matter whether the robots moved by wheels or feet. Also the participants expected a body screen on the robots. Participants' preferences toward the appearances and functions of home service robots suggested that they perceived home ISRs as more like a machine than an agent. With the correlation analysis of robot outlooks and the HRI factors, the results clearly showed that once the appearance of the home ISRs is suitable for users, the likability and trustworthy could also be enhanced.

This study conducted a multidimensional development of home ISRs through the survey. The preliminary findings of the study answered the questions about what robots can do, how they look like and how the interaction between human and robots. To figure out the demanding differences in gender and buying tendency, the comparisons were also conducted and found out some interesting results. The designers in the future can consider the differences in different groups to design more favorable and useable home ISRs for each possible owner.

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