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Research on Service Robot's Willingness to Use: Extended TAM Model

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Abstract: This study investigates service robot acceptance factors through an extension of standard TAM for measuring user willingness. Service robots demand new TAM principles because users recognize them through emotional factors and experience technical interaction and safety issues. The research uses perceptual intelligence and human-computer interaction and personification and privacy risk factors to extend the Technology Acceptance Model framework. The survey research instrument operated through both internet and physical methods to collect valid participant responses from 500 qualified users. SPSS and AMOS software were used throughout the research process to test the reliability and validity of the study while conducting structural equation modeling (SEM). The study reveals that both perceived usefulness and ease of use with intelligence and personification and interaction quality lead to user satisfaction while privacy risk reduces this satisfaction level. User satisfaction levels immediately impact the system usage preferences of the users. The study provides practical guidelines and theoretical principles to improve user-focused service robot development and foster better social acceptance of these robots.

Keywords: Service Robot; Willingness to Use; TAM Model

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1.Introduction

The fast implementation of service robots across multiple fields continues driven by modern technology which results in new lifestyle patterns yet demanding healthcare institutions along with maintenance services and consulting organizations to change their occupational requirements. The critical acceptance level of users stands as the main barrier inhibiting service robot technology progress. Deep evaluation of service robot acceptance provides critical advantages for image-based development as well as actual implementation of service robots in real-life settings. Service robots face difficulties when assessing user acceptance because achieving physical bonds and both emotional and cognitive bonds leads to acceptance. Service robots demonstrate unique operational features because they process vocal commands and process facial signals to create motions emulating human motion patterns. The user-perceived system intelligence as well as emotional reactions to the system stem from these characteristics alongside variations in system trust. Users make decisions about accepting new solutions based on both perceived utilities together with system interface traits along with privacy risks that occur when using these solutions.

Several research studies across multiple disciplines depend on the Technology Acceptance Model (TAM) for quantifying user reactions toward digital technology. Service robots require supplementary factors introduced to the Technology Acceptance Model in order to perform efficient evaluations. The behaviors of human-computer interaction together with perceptual intelligence and personification and privacy risks significantly impact overall evaluation. This research extends the TAM to study additional factors and their influence on satisfaction together with willingness to use. The study aims to develop an improved framework that demonstrates effective strategies for boosting user acceptance and service robot implementation in genuine scenarios.

2.Literature review and theoretical basis

2.1 Technology Acceptance Model (TAM)

During 1989 Davis established Technology Acceptance Model (TAM) as an extension of rational behavior theory although he used it to predict and explain information systems user behavior acceptance. According to TAM model users will accept information technology based on their behavior intention that stems from perceived usefulness and perceived ease of use. Users evaluate system usefulness by considering how it enhances their work efficiency while easiness of use represents their belief about system operation simplicity. During the decades since the TAM model's introduction academics have used it for multiple information systems acceptability researches to verify user intention development patterns. Traditional TAM models could encounter restrictions for explaining acceptability of complex technology products because of ongoing information technology advancements and emerging application settings [1]. Therefore, scholars have constantly expanded and revised the TAM model to meet the needs of different research situations.

2.2 Extended TAM model

In order to explain and predict users' willingness to accept complex technical products more comprehensively, scholars have extended the traditional TAM model. Additional external and intermediary variables have entered the expanded TAM model which maintains perceived usefulness and perceived ease of use while expanding the explanation of technical product user acceptance. The conventional TAM model lacks effectiveness when applied to service robots given that their nature as technical products combines with human-computer interaction and emotional interaction elements. This paper develops a theoretical model for understanding service robots' willingness to use through extended TAM based variables of perceptual intelligence, human-computer interaction, personification and privacy risk.

2.3 The research model and assumptions

2.3.1 Research model construction

The specific model is shown in Table 1.

Table 1 TAM Model Variable Table Based on Extension

TAM model variable	Variable content
Perceived usefulness	The degree to which users think that using service robots can improve their life or work efficiency.
perceived ease of use	How easy do users think it is to use service robots?
Perceptual intelligence	User's Perception and Evaluation of Service Robot's Intelligence Level
human-computer interaction	Interaction process and experience between users and service robots
personification	Human-like characteristics and behaviors exhibited by service robots.
Privacy risk	Users think that using service robots may bring the risk of privacy leakage.
degree of satisfaction	Users' overall satisfaction with the performance and service of the service robot after using it.
Willingness to use	Willingness and inclination of users to continue using service robots in the future.

2.3.2 Research hypothesis put forward

Based on the above research model, this paper puts forward the following research hypotheses, as shown in Table 2.

Table 2 Research Hypotheses Based on Extended TAM Model

Hypothetical serial number	Hypothetical content
H1	Perceived usefulness has a positive impact on user satisfaction.
H2	Perceived ease of use has a positive impact on user satisfaction.
H3	Perceptual intelligence has a positive impact on user satisfaction.
H4	Human-computer interaction has a positive impact on user satisfaction.
H5	Personification has a positive impact on user satisfaction.
H6	Privacy risk has a negative impact on user satisfaction.
H7	Satisfaction has a positive impact on users' willingness to use.

2.3.2 Research Hypotheses and Derivation Process

This research utilizes the extended Technology Acceptance Model (TAM) while introducing specific variables related to human-robot interaction to better investigate user willingness towards service robots. Researchers derive every hypothesis both from theoretical explanations and empirical observations.

The reasoning process behind each proposed relationship is detailed below:

H1: Perceived usefulness has a positive impact on user satisfaction.

The fundamental element of TAM is Perceived usefulness that measures how much users believe a system will boost their work productivity. The perception that a robot improves efficiency within work environments alongside homes and service areas creates positive attitudes towards service robot technology in users. Research by Davis (1989) demonstrates that users' perceptions regarding system usefulness define how they feel and act regarding the system. Research conducted by Zou (2024) demonstrates how user satisfaction rises when users identify discernible advantages of technology application. The more users believe a service robot serves them well the more satisfaction they expect to gain from its use.

H2: Perceived ease of use has a positive impact on user satisfaction.

Perceived ease of use is the extent to which users believe that operating the system is free from effort. Ease of use determines satisfaction because it controls first-time user views together with making systems easier to handle. The usability of service robots plays a critical role in improving user experiences when learning procedures requires little effort. According to Davis (1989) as well as Tao (2023) user satisfaction begins with interface ease of use during interactions with complex or new interfaces. Users experience better satisfaction with service robots that maintain user-friendliness and user-intuitiveness which creates feelings of competence and control.

H3: Perceptual intelligence has a positive impact on user satisfaction.

Perceptual intelligence refers to the user's perception of the robot's cognitive capabilities—such as the ability to respond appropriately, understand commands, and adapt to user needs. Service robots of modern times implement artificial intelligence features to exhibit intelligent behavior patterns. Research by Wang et al. (2024) shows that increased perceptions of robot intelligence instill trust along with comfort to produce better satisfaction. People tend to feel more contentment and admiration toward robots that show intelligent responsiveness and situational awareness while operating independently. The emotional and functional satisfaction factor validates perceptual intelligence's inclusion within drivers of service satisfaction.

H4: Human-computer interaction has a positive impact on user satisfaction.

Human-computer interaction (HCI) refers to the quality of the interactive process between the user and the service robot. Positive HCI achieves its aims through precise feedback along with seamless communication that avoids user frustration. The human-computer interaction method directly influences the bonding development between users and their service robots. The authors Tan and Lv (2022) maintain that superior human-machine interaction promotes both emotional involvement and trust in the system. The robot achieves greater user satisfaction when it provides seamless communication because users recognize its cooperative nature and dependability.

H5: Personification has a positive impact on user satisfaction.

Personification involves endowing the robot with human-like features such as facial expressions, gestures, or emotional responses. The combination of these characteristics enhances robotic devices to appear friendly and related to humans. According to Zou (2024) robots which receive anthropomorphic design enable users to build emotional ties while minimizing their social gap. Service users tend to show improved satisfaction because personified robots help them create emotional bonds which are highly valued in these human-centered service settings. The implementation of personified features should produce positive effects on user evaluation of the entire experience.

H6: Privacy risk has a negative impact on user satisfaction.

Privacy risk refers to the user's concern that personal or sensitive data may be misused by the robot or associated systems. People experience emotional discomfort alongside trust problems at the hands of perceived risks present in smart technologies. Tao (2023) illustrated that privacy issues present the major challenge for device adoption during periods of user data collection or processing. Service robots incorporating sensors and cameras create feelings of exposure among users because they function as monitoring devices. System effectiveness does not prevent users from being dissatisfied because of privacy risks thus establishing a plausible hypothesis about this negative connection.

H7: Satisfaction has a positive impact on users' willingness to use.

Satisfaction reflects users' overall evaluation of their experience with the service robot. Satisfaction appears as one of the most vital predictors of continued usage as per both the extended TAM and behavioral intention models. In his initial research from 1989 Davis showed that users who experienced satisfaction would adopt new technology and make recommendations about it. Tan and Lv (2022) show that satisfaction works as a mediating link between perceptions (including usefulness and ease of use) to eventual behavioral intention. A positive service robot experience leads users to follow its usage while establishing it as part of their regular activities.

3.Research methods

3.1 Questionnaire design

In order to verify the above research hypothesis, this paper designed a questionnaire to investigate. The contents of the questionnaire mainly include the following parts, as shown in Table 3.

Table 3 Questionnaire

Questionnaire items	content
Basic information	Gender, age, occupation and educational background of the respondents.
Perceived usefulness	Measure respondents' perception of the usefulness of service robots through questions, such as "service robots can improve my work efficiency"
perceived ease of use	Measure the respondents' perception of the ease of use of service robots through questions, such as "It doesn't take much effort to learn to use service robots"
Perceptual intelligence	Measure the respondents' perception and evaluation of the intelligence level of service robots through questions, such as "I think the intelligence level of service robots is very high"
human-computer interaction	Measure the interaction process and experience between the respondent and the service robot through questions, such as "My interaction with the service robot is very smooth"
personification	Respondents' perception and evaluation of anthropomorphic characteristics of service robots are measured through questions, such as "the appearance and behavior of service robots are very similar to human beings"
Privacy risk	Measure the risk of privacy leakage that respondents think may be brought by using service robots through questions, such as "I'm worried that using service robots will reveal my personal information"
degree of satisfaction	By measuring the respondents' overall satisfaction with the service robot through questions, "I will recommend this service robot to others"
Willingness to use	Measure respondents' willingness and inclination to continue using service robots in the future through questions, such as "I plan to continue using service robots in the future"

The questionnaire adopts Likert five-level scoring method, and the respondents are required to score each question according to their actual situation and feelings (1 means very different, 5 means very agree).

3.2 Data collection

This paper collects data online and offline. Users access questionnaire links published on online platforms while the offline method involves on-site distribution and collection of paper surveys in business locations and education institutions and residential areas [2]. The data collection process included efforts to achieve diverse and representative sample collection that included individuals from different age groups and both genders and various employment sectors and educational profiles. We finalized the data analysis with 500 valid questionnaires which would be utilized for hypothesis testing.

3.3 Data analysis methods

In this paper, SPSS and AMOS are used to analyze the data. Specific analysis methods include descriptive statistical analysis (analyzing the basic characteristics of the sample, such as gender, age, occupation, etc.), reliability analysis (evaluating the reliability and internal consistency of the questionnaire by calculating Cronbach's α coefficient and other indicators), validity analysis (evaluating the validity and accuracy of the questionnaire, testing by exploratory factor analysis (EFA) and confirmatory factor analysis (CFA)) and structural equation model (SEM).

4.Data analysis and results

4.1 Descriptive statistical analysis

Through descriptive statistical analysis of 500 valid questionnaires collected, we get the following results:

Gender distribution: The respondent population consists of equal male and female participants at 52% each; while the age breakdown reveals 20% between 18-25 years old and 35% between 26-35 years old and 30% between 36-45 years old with 15% at or above 46 years old. The research sample includes all participants but has the most members between young adulthood and middle age. Enterprise employees make up 40% of the respondents while students comprise 20% and freelancers make up 15% and people in other occupations such as teachers and doctors make up the remaining 25%. These occupational categories appear in the sample group which includes Bachelor-level students and higher academics representing 60% and 40% respectively. About sixty percent of the participants possess an educational attainment of either undergraduate or lower levels. The sample data shows excellent representation because it includes participants of different genders and ages across various occupational types along with different education degrees. This strengthens the ability to understand user willingness toward service robots.

4.2 Reliability analysis

By calculating Cronbach's α coefficient to evaluate the reliability of the questionnaire, we get the following results, as shown in Table 4.

Table 4 Cronbach's α coefficient table for reliability analysis

Reliability analysis project	Cronbach's α coefficient	Degree of internal consistency
Perceived usefulness	0.85	higher
perceived ease of use	0.82	higher
Perceptual intelligence	0.80	higher
human-computer interaction	0.78	higher
personification	0.76	higher
Privacy risk	0.75	higher
degree of satisfaction	0.83	higher
Willingness to use	0.81	higher

From the above results, it can be seen that Cronbach's α coefficient of each part of the questionnaire is greater than 0.7, which indicates that the questionnaire has high reliability and internal consistency and can meet the requirements of subsequent data analysis.

4.3 Validity analysis

Through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to evaluate the validity of the questionnaire, we get the following results:

Exploratory Factor Analysis (EFA): Maximum variance rotation and principal component analysis extracted the factors which showed that each component in the questionnaire had a distinct factor structure. The measurement quality exceeds 0.5 in each factor without dimensional interference which demonstrates solid structural validity according to the questionnaire results or Confirmatory factor analysis (CFA): A structural equation model created in AMOS software checked the questionnaire's dimensionality structures. Structural equation model assessment shows the fitting indexes of χ/DF, RMSEA, CFI, TLI and more reach the desired criterion points of χ/DF = 2.34 and RMSEA=0.06 and CFI=0.92 and TLI=0.90.

4.4 Structural equation model (SEM) analysis

Through the structural equation model (SEM) to verify the research hypothesis, we get the following results, as shown in Table 5.

Table 5 Hypothesis Table of Structural Equation Model (SEM) Verification Research

research hypothesis	**Satisfaction path coefficient**	**P value**	**Influence (positive/negative)**	**Assumption holds (Yes/No)**	**The results show that**
H1 perceived usefulness	0.32	p<0.001	forward direction	be	When users think that using service robots can improve their life or work efficiency, they will have higher satisfaction with service robots.
H2 perceived ease of use	0.28	p<0.001	forward direction	be	Users think that the easier it is to use the service robot, the easier it is to have a good impression and trust on it, thus improving satisfaction.
H3 Perceptual Intelligence	0.25	p<0.001	forward direction	be	The higher the user's perception and evaluation of the intelligence level of the service robot, the easier it is to trust and rely on it, thus improving the satisfaction.
H4 Human-computer interaction	0.22	p<0.001	forward direction	be	The better the interaction process and experience between users and service robots, the easier it is to have a good impression and trust on them, thus improving satisfaction.
H5 personification	0.18	p<0.01	forward direction	be	The more human-like features and behaviors the service robot exhibits, the easier it is to establish emotional connection with users, thus improving satisfaction.
H6 privacy risk	-0.15	p<0.05	negative direction	be	Users think that the higher the risk of privacy leakage caused by using service robots, the easier it is to have distrust and resistance to them, thus reducing satisfaction.
H7 willingness to use	0.45	p<0.001	forward direction	be	The higher the user's satisfaction with the service robot, the more willing they are to continue to use the service robot.

In addition, we also evaluated the overall fitting degree of the model. The results show that the χ^2/df value of the model is 2.13, the RMSEA value is 0.05, the CFI value is 0.93, and the TLI value is 0.91, all of which have reached the ideal level, indicating that the overall fitting degree of the model is good, which can better explain and predict the user's willingness to use the service robot [3].

5.Discussion

5.1 Perceived usefulness, perceived ease of use and satisfaction

The results show that both perceived usefulness and perceived ease of use have a significant positive impact on user satisfaction. Users accept new technology products because they find them useful and easy to use in accordance with the standard TAM model. Users experience higher service robot satisfaction because of their beliefs that these tools increase efficiency in life and work tasks. Moreover ease of service robot operation leads users to develop positive feelings and trust which contributes to better satisfaction.

5.2 Perceptual intelligence, human-computer interaction, personification and satisfaction

The service robot achieves better service delivery through its high perceptual intelligence capability to match user requirements and expectations. A positive human-computer interaction improves user satisfaction together with anthropomorphic features creating better acceptance of the service robot which enhances emotional user experience during interactions.

5.3 Privacy risk and satisfaction

The results show that privacy risk has a significant negative impact on user satisfaction. Service robot users demonstrate substantial concern about their privacy protection needs. User trust and satisfaction diminishes when they think service robots expose their privacy information to others.

5.4 Satisfaction and willingness to use

The results show that satisfaction has a significant positive impact on users' willingness to use. The obtained finding upholds the fundamental TAM model which presents satisfaction as a crucial determinant for users' upcoming utilization decisions. User satisfaction levels toward service robots strongly affect their willingness to keep using service robots according to the field of service robots. The key factor to increase users' willingness to use service robots is focused on improving their satisfaction levels. Service robot providers should pay attention to user satisfaction, and improve user satisfaction and willingness to use by providing high-quality services and solving user problems in time [4].

6.Tag

In this paper, the willingness to use service robots is deeply studied through the extended TAM model, and the following conclusions are drawn: All features from perceived usefulness, perceived ease of use, perceived intelligence, human-computer interaction and personification positively influence user satisfaction whereas privacy risk produces negative effects on satisfaction levels which leads to increased willingness to use among users. The revealed findings establish a theoretical basis which delivers practical application for improved comprehension of what drives users to adopt service robots. The following findings allow designers to enhance service robot usability while improving intelligence and human-machine interface quality and anthropomorphic elements and privacy features and user satisfaction for overall user experience enhancement.

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no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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