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Review of service robot technology acceptance model research

Fangmin Sun *

School of Economics and Management, Tianjin University of Technology and Education, Tianjin 300222, China

*Corresponding Author Email: 15169821303@163.com

ABSTRACT

With the continuous progress of science and technology, service robots have gradually penetrated into various industries, including catering, travel, home and medical fields. The rapid development of this technology has attracted wide attention in today's society, involving artificial intelligence, machine learning, and human-computer interaction, and has brought major changes to our lives and work. However, the adoption of new technologies is not always smooth, and the level of acceptance varies. This paper takes the technology acceptance model (TAM) and its derivative model as the theoretical framework to deeply explore the factors that affect the acceptance of service robots. Various factors revealed by TAM technology acceptance model and its derivative model will be discussed in depth respectively. This study will help to reveal all possible factors that affect user acceptance of service robots, such as functional elements, emotional elements and users' own characteristics, for future research.

KEYWORDS

Service robot; technology acceptance model; Perceived ease of use; Perceived usefulness.

1. INTRODUCTION

With the continuous progress of artificial intelligence technology, the performance of service robots is becoming more and more powerful, and the application scenarios are increasingly rich. Service robots have become a key element that can not be ignored in all walks of life, including but not limited to the service industry, catering, home and medical fields. According to 2020 statistics from the International Federation of Robotics (IFR), global sales of service robots reached $16.9 billion in 2019. Among them, professional service robots accounted for 66% of sales, totaling 11.2 billion US dollars; Personal/home service robots accounted for 34% of sales, totaling $5.7 billion.

In China's market, the service robot industry has also shown an explosive growth trend. From 2014 to 2019, the market has continued to expand, achieving sales of $2.2 billion in 2019, an increase of up to 33.1% year-on-year. The application range of these service robots is constantly expanding, bringing a lot of convenience to improve people's life and work.

However, the introduction of new technology is often accompanied by users' resistance, and users' acceptance and reaction to it have obvious differences. The academic community has recognized that the application of robotics to the field of service is becoming increasingly important. Therefore, an in-depth understanding of the factors that affect the acceptance and response of users to service robots is of great significance for promoting the popularity of service robots.

First of all, users' acceptance of service robots is affected by the maturity of robot technology. Service robots with immature technology may cause distrust and concern from users, while service robots with mature technology are easier to gain user recognition. Second, users' reactions to service robots are influenced by their usage scenarios. For example, in a home environment, service robots may need to be more user-friendly and humanized, while in a business environment, service robots may need to be more efficient and precise. Finally, users' acceptance and response to service robots are also affected by socio-cultural and psychological factors. For example, concerns about robots replacing human jobs may affect user acceptance of service robots. Therefore, for the service robot industry, it is not only necessary to continuously improve the technical level, but also to pay attention to the needs and concerns of users in order to better promote and apply service robots.

However, due to the reluctance of users to accept and use existing robotics technology, enterprises and organizations do not have access to the data that helps machine learning, technology updates and upgrades are limited, and performance improvements are hindered. Due to the permanence and importance of this issue, scholars have also begun to pay attention to and study the acceptance of robot technology by consumers and the influencing factors behind it. So what do consumers think of these emerging robotics technologies? What are the key factors that affect their acceptance of robots?

2. THEORETICAL BACKGROUND

2.1. Technology Acceptance Model

As early as 1989, Fred D. Davis proposed the Technology Acceptance Model (TAM)[1], which aims to explain and predict users' acceptance of new technologies. According to the TAM model, users' acceptance of technology is mainly influenced by two factors: Perceived Usefulness and Perceived Ease of Use. Perceived usefulness is defined here as "the degree to which a person believes that using a particular system will improve his or her job performance." Perceived ease of use refers to "the degree to which a person believes that using a particular system is effortless"[1]. According to previous research, perceived usefulness and perceived ease of use simultaneously determine whether a new technology will be adopted by consumers. In other words, a technology or product is more likely to be accepted by users if it makes them feel that it contributes to efficiency or a better experience.

The theoretical importance of perceived usefulness and perceived ease of use as determinants of user behavior is indicated by several diverse lines of research. First, the importance of perceived ease of use is supported by self-efficacy research. Self-efficacy is an individual's confident belief in his or her ability to complete a specific task[2]. The concept of self-efficacy is similar to perceived ease of use. The key determinant of technology adoption is that a person believes that he or she can successfully use the technology and believes that he or she can easily use the technology. Secondly, the cost-benefit paradigm in behavioral decision theory is also related to perceived usefulness and ease of use. According to the cost-benefit paradigm[3-4], people's choices among various decision-making strategies are determined by a cognitive trade-off between the effort required to use the strategy and the quality (accuracy) of the final decision. This explains why decision makers change their selection strategies in response to changes in task complexity. And finally, Research on the adoption of innovations also suggests a prominent role for perceived ease of use. In their meta-analysis of the relationship between innovation characteristics and adoption, Tornatzky and Klein(1982) found that compatibility, comparative advantage, and complexity have the most consistent significant relationship across a wide range of innovation types[5]. Previous research has defined complexity as "the degree to which an innovation is perceived to be relatively difficult to understand and use," which is similar to the definition of perceived ease of use. In addition, previous studies on the evaluation of information reports in management information systems also echo the distinction between perceived ease of use and usefulness. Among the two factors in factor analysis

conducted by Larcker and Lessig(1980), each factor has three items, among which perceived importance refers to "enabling specific information sets to acquire quality relevant to decision makers". And the degree to which information elements are "necessary inputs to complete tasks", as well as perceived usability, which is defined as the degree to which "information is in a clear, clear, or readable format", these two dimensions are similar to perceived usefulness and perceived ease of use[6].

Therefore, in order for a system or new technology to be more easily accepted and recognized by users, it must first be practical and can help users complete tasks more efficiently. Other conditions are equal, those simpler and more convenient to use technology will be more easily accepted and used by the majority of users. Therefore, when developing new technologies or designing new products, we must fully consider the needs and experiences of users to ensure that they are both practical and easy to operate.

2.2. Technology Acceptance Model 2

Following the classic TAM model, Viswanath Venkatesh and Fred D. Davis published the TAM2 model in 2000. This new model aims to extend and deepen the technology acceptance model theoretically from a broader perspective. To this end, the researchers conducted four longitudinal studies in order to more fully uncover and validate the complex factors involved in technology adoption.

Compared with the original TAM model[7], TAM2 introduces two new constructs: the Cognitive Instrumental Process and the Social Influence Process. These two new constructs add a rich layer and depth to the model.

The former focuses on how technology can be used as a utility to help users perform their tasks more efficiently and with higher quality. This process involves work relevance, output quality, demonstrability of results, and perceived ease of use[2]. In short, it focuses on how technology actually helps users and how users form attitudes toward technology based on those practical helps. When users deeply feel that a technology can play a positive role in their work, improving the efficiency and quality of task completion, they are more inclined to have a positive evaluation of the technology.

The latter focuses on the more subtle and complex social and psychological factors involved in technology adoption. This process covers subjective norms, voluntariness and image[7]. Different from the cognitive tool process, it focuses more on how individuals form their attitudes and opinions toward a certain technology under the influence of others' opinions and social norms[7]. For example, when users are surrounded by people who use and promote a certain technology, they are likely to be influenced by this social atmosphere and are more likely to accept and adopt the technology. In addition, some of the more macro social norms, such as the policy orientation of the organization or the general expectations of the public, may also subtly affect the acceptance of technology by individuals.

The study also found[7] that both cognitive tool processes and social influence processes play an indispensable role in the formation of users' technology acceptance attitude. In particular, it is worth mentioning that the factor of subjective norms has a direct impact on users' intentions in the context of mandatory use, but not in the context of voluntary use. This discovery provides us with a deeper and more detailed insight, making our understanding of the TAM model more comprehensive and accurate.

2.3. Augmenting the Technology Acceptance Model

Building on the technology acceptance model, the AAM model innovatively introduces a trust factor, a move designed to take a deeper look at how trust enhances the technology acceptance model and

specifically examine commercial driver attitudes toward on-board monitoring systems (OBMS). This extension not only enriches the explanatory power of the model, but also makes the model more close to the actual application scenario.

This paper adopts the method of empirical research, through systematic data analysis and processing, the paper reveals the overall attitude of commercial drivers to the monitoring and feedback system. More importantly, the paper also found that drivers with different individual characteristics have significant differences in their attitudes towards monitoring and feedback. These findings provide a strong basis for personalized promotion and application of vehicle monitoring system.

The research draws an important conclusion: perceived usefulness and trust play an important role in determining drivers' willingness to use, and trust can indeed enhance the technology acceptance model and improve drivers' acceptance of monitoring and feedback[8]. This finding not only enriches the technology acceptance model in theory, but also emphasizes the importance of trust in technology promotion in practice. Trust is also a major determinant of use intent[8], which is particularly evident in modern society. Take online shopping as an example, consumers pay to place an order without seeing the actual product, which is behind the great trust in the platform. Without trust, consumers will not choose to make purchases on platforms they do not trust. This phenomenon is similar to the attitude of commercial drivers towards on-board monitoring systems, further highlighting the key role of trust in technology applications.

However, perceived ease of use has little impact on usage intention, which is inconsistent with TAM literature studies. These contradictions may be due to differences between modeling frameworks, as well as differences in the nature of driver assistance systems and their use contexts.

2.4. The Almere Model

The Almere model[9] is adapted and extended based on the Technology acceptance model (TAM)[1] and the Unified Theory (UTAUT) model[10], which mainly discusses the acceptance degree of assisted social agency technology among the elderly. The UTAUT model is based on the original TAM, Other factors included include Social Influence, Facilitating Conditions, Intention to Use, Perceived adaptiveness, Perceived Enjoyment, and Perceived Sociability, Actual Use, Social Presence, etc. This model has been applied to study user acceptance of social robots. These studies found that compared to introverted social robots, participants perceived extroverted robots to be more expressive and socially intelligent, and therefore more willing to accept them[11]. UTAUT also seems to have been used to study the acceptance of social robots by older users, as de Ruyter et al. (2005) point out that the model may be applicable to human-computer interaction.

The Almere model also added anxiety and usage attitude on the basis of TAM model and UTAUT model, and adapted all variables to the levels of each variable measured by questionnaires for older participants. The three experimental results show that attitude is also one of the most important factors affecting usage intention. But attitudes and trust may change over time to some extent, and for participants, as they get older and their needs vary, their attitudes toward assistive technologies, and especially toward assistive social robots, may change. The experimental data is only a short period of measurement results, and this experimental result needs to be confirmed by long-term research.

The application of the Almere model will help promote the popularization and development of technology to improve the quality of life of the elderly. By optimizing technology design and user experience, the needs and expectations of the elderly can be met and their acceptance of technology can be increased.

2.5. Car Technology Acceptance Model

CTAM model[12] introduced two factors of "anxiety" and "perceived safety" on the basis of TAM to conduct an in-depth study on the acceptance of automobile technology. The application of the

technology acceptance model in the automotive environment needs to consider its characteristics. The driver's position is fixed, his main attention is focused on driving the car, and his surrounding environment is always changing. Therefore, the interaction mode is also an influential factor that affects the user's acceptance of automotive technology.

A distracted driver is more likely to be in a dangerous driving situation, so perceived safety may affect the driver's technical acceptance of information systems in the automotive environment.

The model can help researchers and enterprises understand the user's acceptance and use behavior of information technology in vehicles. Through the analysis of the key factors affecting the acceptance of automotive technology, the user's attitude, needs and expectations of different automotive technologies are revealed, so as to provide targeted improvement suggestions for automobile manufacturers and technology developers.

2.6. Service robot Acceptance model

sRAM model[13] is a service robot acceptance model developed on the basis of TAM model. According to the technology use model (TAM), the customer's intention to use new technology depends on the cognitive evaluation of the perceived usability and perceived usefulness of the robot. However, in the interaction process between the service robot and the customer, attention should be paid not only to whether the service robot can provide the core service, but also to provide the social emotion and relational elements of the service. When designing the service robot usage model, Wirtz et al. (2018)[13] added social emotion and relationship factors in addition to functional factors such as perceived ease of use and perceived usefulness.

First of all, Fiske et al(2007) argued[14] that warmth and competence are the two basic dimensions of social cognition. Warmth and competence are the judgment criteria that help users understand and perceive others, and can predict the user's next behavior[15]. Competence is generally associated with functional outcomes of interactions, while warmth is associated with social outcomes[16]. Social cognitive theory provides a theoretical basis for how customers evaluate service robots.

Secondly, role theory also provides additional theoretical basis for how customers perceive and evaluate service robots[17]. A role in role theory is a set of functional, social, and cultural norms that determine how the interacting parties (i.e., service providers or service robots and customers in this article) should act in a given situation[18]. Role theory states that both actors should act according to socially defined roles in order for role consistency to occur, or if an actor does not conform to a prescribed role, role inconsistency will occur. In conclusion, it is reasonable to assume that consumer acceptance of service robots depends on the robot's performance in meeting functional needs (i.e., related to dominance) and social-emotional and relational needs (related to warmth) to achieve role consistency[13].

Since the service robot can have a dialogue with the user, even if the user makes an error, the user can pass information with the service robot through the dialogue and complete the task. Service robots are different from self-service technology, the functions of self-service technology are set in advance, if customers can not accurately operate self-service technology (such as self-service ticket machines), may get into trouble, unable to complete the transaction, service robots can be a good way to avoid this situation. Perceived ease of use versus perceived usefulness seems to be a given for self-service technology and will be a barrier if not delivered at the level required by customers. On the contrary, service robots can provide services according to the needs of customers. Therefore, social emotion (perceived humanity, perceived social interaction and perceived social presence) and relational elements (trust and rapport) are included in the service robot usage model.

3. DISCUSSION

First, through the evolution of the above-mentioned technology acceptance model or service robot acceptance model, scholars have found the importance of social emotion and relational factors in evaluating user acceptance. For individuals to adopt and use a new technology, the initial requirements must be the ease of use of the technology and the benefits of using the technology. For example, using a logistics delivery robot to pick up my express is not only easy for me to operate, but also brings convenience to my life. I will choose to use a logistics delivery robot to pick up my express. However, as people's requirements for quality of life continue to improve, tasks based on industrial robots are no longer so simple, and robot technology must not only be equipped with programs that can complete basic tasks, but also, in some cases, need to have some emotional elements. The delivery robot will also design some anthropomorphic language to use in necessary situations, such as when there are obstacles ahead or pedestrians passing by, the robot will say "Please make way, you are blocking me", which is no longer a concept, but a reality. The purpose of doing so is not only to improve the user's perception of the ability and autonomy of the logistics distribution robot, but also to increase the interest of pedestrians passing by this technology, so as to generate the intention to use it. According to the theory of mental perception[19], people need to perceive machine intelligence through two dimensions of cognitive intelligence and emotional intelligence, and the development of robots is constantly enhancing cognitive intelligence and perceptual intelligence. Therefore, the expansion and evolution of technology acceptance model should pay attention not only to the cognitive intelligence dimension, but also to the emotional intelligence dimension of technology.

Secondly, the influence of other factors can be considered in future research on technology use, although the existing technology acceptance model already covers both cognitive dimension and emotional dimension. But the user's own characteristics will also be a key factor affecting the use and acceptance of technology. For example, the impact of individual interpersonal interaction needs on technology acceptance, interpersonal interaction needs have been proved to be a psychological need, related to the surrounding environment or tasks, users with high interpersonal interaction needs are eager to contact with human employees, and do not like to deal with technology. In turn, users with low need for human interaction like to challenge new technologies and tend to engage with technology-related services or products. Therefore, users with different interpersonal interaction needs will have very different attitudes and views towards a new technology, and it is crucial to consider user characteristics similar to interpersonal interaction needs when studying technology acceptance models.

Finally, the acceptance and use of a new technology also has a lot to do with the service environment. In the traditional robot service environment, what users care about is whether the technology can successfully perform the task and meet the needs. In this relationship, perceived usability and perceived usefulness are the key variables that determine the user's adoption of the technology, just like the applicable environment of TAM model. However, in service environments such as hotels and restaurants, where a technology needs to interact with customers face to face, a technology needs to have not only the ability to successfully perform tasks, but also some ability to meet the emotional needs of customers. The service environment in which service robots are implemented requires "humanized" services, and customers expect human-like interaction with robot technology, which contributes to the continuous use intention of customers. Therefore, depending on the service environment, the determinants of technology acceptance will be different.

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