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Short Research Paper

The Use of Service Robots in Service Delivery: A Review of the Literature

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Abstract: Service robots as emerging service providers, in combination with novel technologies like artificial intelligence, have the potential to enhance service outcomes and customer experience and may already be transforming the service delivery process. At present, the study focused on service robots has matured sufficiently to warrant an overview of the research on the ways in which service robots have been employed. This study conducts a systematic literature review of the academic corpus focused on service robots (N = 28). We report the research methods, application contexts and robot types of service robot research to understand how service robots participate in service delivery, what technological characteristics of service robots are commonly analyzed, and the potential service outcomes of service robot use. This review shows that overall, service robots have a high potential to delivery services in service contexts, and will be widely used and bring more rich service experience to people.

Keywords: service robot, service delivery, literature review

1. INTRODUCTION

Wirtz et al. [1] defines service robots as system-based autonomous and adaptable interfaces that interact, communicate with and deliver service to an organization's customers. As emerging service providers integrating advanced and new technologies, service robots are increasingly transforming the customer experience (e.g., empowerment) [2] and service outcomes (e.g., customization and personalization) [1]. Studies have shown that robots afford service delivery with some characteristics such as convenience, availability, and empathy [2-3]. With the potential for service innovation, development of service robots has been highlighted in many countries, espeicially in the post-era of COVID-19 pandemic [3]. According to estimates from the International Federation of Robotics (2020), sales of service robots will reach annual growth rates of over 30% by 2023.

Currently, service robots have been widely used in service practice [4-7]. Many studies have examined consumers' and employees' attitudes toward, reactions to, and acceptance of service robots [8-9]. In addition, for service enterprises, the introduction of service robots reduces service costs, improves service efficiency and innovates the way of service provision. However, service robots also brings new challenges to the management of service enterprises [10-12]. Business practitioners do not seem to have full confidence in the future of the service robot due to its unknown effects as well as its applicable contexts, and hence, there has been a growing interst in these matters lately. Considering that there are a bunch of research studying service robots, what is still remain unclear that what are the inferior or superior customer experience under service robots. Therefore, it is necessary to provide a holistic view of research into the effects of service robots in the extant academic corpus.

Therefore, the purpose of this paper is to summarize and explain the current literature on service robots' participation in service delivery to investigate where and how service robots have been employed in service contexts, what is known about the effects of their implementation, and which potential future research directions could be most beneficial.

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2. METHOD

This paper is guided by the methodology of Kitchenham [13] and Brereton et al. [14]. In this section, we begin our analysis with a literature review structured in three sections: search strategy, study selection, and data extraction from the collected literature.

2.1 Search strategy

The search was performed in March 2021. Considering that the research on service robots is still in its initial stage, there are many related phrases, such as "service assistant." We executed the search query "service robot," "robot service," "robot server," "electronic staff," "humanoid/humanlike robot," "social robot" and "service assistant" within the title and abstract as well as keywords. For an exhaustive literature search, Brereton et al. [14] suggested targeting different bibliographic sources; thus, we searched Web of Science, Science Direct, Emerald, and Springer Link. These databases cover the majority of representative research related to service robots and are thus adequate for collecting literature pertaining to the participation of service robots in service delivery.

2.2 Study selection

Our main inclusion criterion was the analysis of the robotic service in service contexts, with a primary focus on service outcomes rather than on design methods, infrastructure, or the functionality-related aspects of robots. We used "service* robot*" to search in Web of Science and found that the number of documents published exceeded 100 in 2010. We predicted that the service robots' research, application practice and technology maturity have made great progress after 2010. Therefore, it can be expected that the recent experience of using service robots is considerably different than it was ten years ago. So we searched for studies published between 2010 and 2020. Regarding the type of literature, we only considered published journal articles.

The study selection procedure is shown in Figure 1. First, 3,431 publications were obtained by the search query. Second, we removed duplicates and screened the titles, abstracts, and conclusions to exclude the ones further that either were inaccessible or did not fit into our research scope. Then, the corpus is reduced to 384. Third, we analyzed the full text of the remaining articles and excluded another 359 studies (based on our inclusion/exclusion criteria stated above). Finally, we searched references of the included papers (backward search) and papers that referenced our identified pool of studies (forward search), and three additional records were identified, and 28 papers were ultimately considered in this review (see Table 1).

Table 1. Final pool of reviewed literature

Reviewed literature
[1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [28], [29], [32], [33]

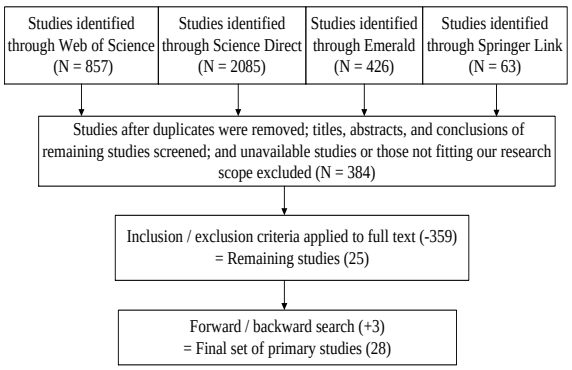

Figure 1. Study selection procedure

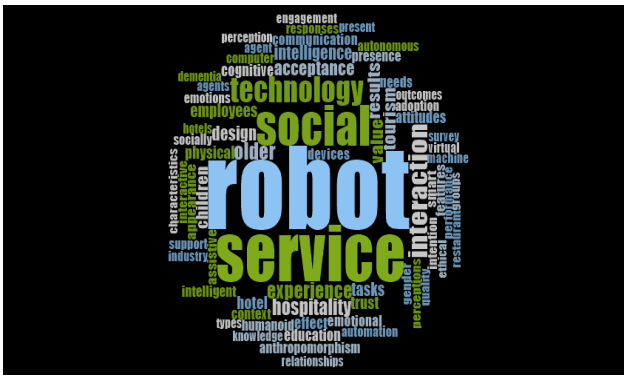

Figure 2. Word cloud of the literature

2.3 Data extraction

We used text mining software Nvivo for data extraction, as shown in the word cloud in Figure 2, from which we can see that current studies pay more attention to the service contexts, service outcomes and technological characteristics of service robots. We randomly selected five publications from the academic corpus and tested whether our results were broadly consistent with our data extraction by extracting relevant information. The results show that our extraction is reasonable and the research methodology is scientific.

3. RESULTS

It is because of a specific characteristic of service robots that affects their application in specific context and cause a specific service outcome [2, 7]. Therefore, this paper will be carried out from three aspects: where and how have service robots been employed in service delivery? What are the technological characteristics of service robots? and what are the effects of using service robots in service delivery?

3.1 Where and how have service robots been employed in service delivery?

Table 2 briefly presents the employed research methods, application contexts and robot types, respectively. In the reviewed body of literature (N = 28), service robots were predominantly researched based on qualitative methods such as conceptual research and user focus group interviews (see Table 2), which were used for exploratively understanding the service outcomes and customer experience associated with service robots [5, 7, 15]. Compared to qualitative methods, quantitative methods like experiment are used less often in service robot research. In addition, there are some studies used mixed methods. For example, Qiu et al. [7] used literature review and in-depth interviews to develop a conceptual framework of the relationship between service robot attributes and customer experience, and then used experiment and survey methods to test the model. We encourage the use of hybrid methods in service robot research.

Table 2. Overview of service robots in service delivery

Research methods	Percentage	Application contexts	Percentage	Robot types	Percentage
User focus group interview	0.18	Tourism and hospitality	0.33	No specific	0.43
Design & prototyping	0.15	Elderly care	0.24	Care robot	0.04
Expert interview	0.04	No specific	0.22	Hospitality robot	0.22
Conceptual/research	0.25	Education	0.02	Social robot	0.12
Case study	0.02	Home care	0.06	Household robot	0.09
Review	0.09	Health care	0.04	Robotic agent	0.02
Evaluation	0.09	Retail	0.04	Frontline robot	0.02
Survey	0.20	Entertainment	0.02	Shopping assistant	0.02
Experiment	0.12	FinTech	0.02	Robo-advisor	0.02
				Teaching assistant	0.02

With regard to application contexts, Table 2 shows that the use of service robots in public environments (e.g., tourism and hospitality) is growing rapidly. Service robots are expected to play as tools and partners. Tools imply that service robots are expected to provide physical assistance to humans, while partners are expected to engage in service interactions and provide emotional support to humans [10]. Service robots have great potential in the context of daily care for the elderly. Service robots are believed to have the potential to support elderly individuals' lives physically, cognitively, and socially, and are also thought to offer a way to fulfil older adults' desire to remain in their own homes and to dispel loneliness [11]. Moreover, service robots show great potential in special contexts, such as education [22] and FinTech [26].

There are different types of service robots and perform different functions in various service contexts. For example, in the hotel context, hospitality robots provide customers with reception and entertainment services.

When the term "social robot" has been used to describe a service robot, it is more emphasis on service robots participating in social interactions [27]. Social robots have been wide to provide companionship and psychological support for customers [6, 28]. For example, Khaksar et al. [28] focused on the PaPeRo robot, which was designed to provide emotional interaction. In addition, service robots also have special designations based on their duties in some specific service contexts, such as robo-advisors in the FinTech context and teaching assistant robots in the education context.

3.2 What are the technological characteristics of service robots?

Existing studies focus on the effects of service robots' participation in service delivery and examine the impact of the technological characteristics of service robots on service outcomes and the customer experience in service delivery (see Table 3). In the extant literature, service robots can be summarized as having three key design characteristics: physical embodiment, social interaction, and data-driven design. The physical embodiment emphasizes the dynamic coupling between the brain, body and environment of service robots, with particular attention to the physical morphology of service robots [29]. Morphologically, robots can be characterized into several groups: anthropomorphic (human-like), zoomorphic (animal-like), caricatured (cartoonish) and functional (an appearance that indicates the robot's core functionality) [30]. Among these morphologies, anthropomorphism has attracted the most scholarly attention. Robots with more human-like features are more likely to inspire trust, be perceived as more sociable and intelligent, and induce customers to rate their usefulness and capabilities higher than mechanical robots [18].

Table 3. Technological characteristics of service robots

Element	Component	Construct	Percentage
Physical embodiment	Morphology	Anthropomorphic	0.27
		Zoomorphic	0.04
		Caricatured	0.00
		Functional	0.18
Social interaction	Presence	Self-presence	0.00
		Physical presence	0.16
		Social presence	0.37
Data-driven	Data acquisition and processing	Data acquisition	0.35
		Data processing	0.35
		Decision-making	0.27

The second key technological characteristic of service robots is social interaction. Jorling et al. [16] showed that encounters with service robots are perceived as social interactions. Another study [29] uses "presence" to refer to how a robotic agent presents to humans. The three types of presence are self, social and physical [31]. In existing studies, self-presence is rarely involved, while physical presence has been found to positively impact a lot of attitudinal measures [29]. In terms of social presence, the extent to which technology enables customers to perceive the existence of another social entity, namely, automated social presence, is a good explanation [18]. Service robots have a higher level of social presence than other service technologies because of the combination of technology autonomy and physical embodiment [16].

Third, data-driven design is considered a significant aspect of service robots and is most salient in three capabilities exhibited by these robots: data acquisition, data processing and decision making. Robots are widely considered capable of performing complex tasks because they can make decisions autonomously based on the data they receive [1]. For example, Portugal et al. [12] described, service robots benefit from a network of sensors and monitors, so during activities in the home environment, they collect user and environmental data and store it in a database; then they retrieve, parse and process data from the intelligently managed database; and finally,

they use cognitive reasoning and intelligent algorithms to make decisions.

3.3 What are the effects of using service robots in service delivery?

All of the reviewed articles generally reported positive outcomes and support the effectiveness of service robots in service delivery (see Table 4) [1-2, 9, 19], as well as how service robot characteristics influence service performance [3, 7, 17-18]. As presented in Table 4, most studies investigated the effects of service robots on the cognitional, motivational, social and emotional dimensions of service outcomes. Obviously, cognitional and emotional outcomes received more attention from the collected literature (see Table 4). From a cognitional viewpoint, we found that the most established variables in service robots are the fundamental elements in the technology acceptance model (TAM): perceived usefulness and perceived ease of use [10, 12, 22]. TAM's explanatory power and wide applicability in service robot research were confirmed to determine the adoption of service robots [1, 8-9]. However, it is also evident that the adoption of service robots seems to be not fully explained by the TAM. For example, based on the TAM, Wirtz et al. [1] proposed the service robot acceptance model after considering the social-emotional aspects, humans' needs, and the congruency of robots with their assigned roles. At the same time, cognitive theories such as social cognition theory have been employed to help explain the adoption and effects of service robots [6-7, 18]. Moreover, studies have noted the potential risks that service robots may pose during service delivery, such as privacy and safety [2, 15, 16, 22].

Table 4. Service outcomes of service robots in service delivery

Cognitional dimension	Percentage	Acceptance/intention to use	0.14
Perceived usefulness/utilitarian	0.51	Engagement	0.24
Perceived ease of use	0.31	Acceptance/intention to use	0.14
Perceived credible/effective	0.27	Social dimension	Percentage
Perceived risks (safety, privacy, bias, ethics)	0.22	Connectivity	0.18
Perceived low cost/service enhancement	0.12	Lack of human touch	0.04
Perceived response is slow/not very reliable	0.06	Emotional dimension	Percentage
Perceived affinity	0.06	Enjoyment/comfort	0.24
Perceived controllability	0.06	Companion	0.24
Perceived dull/inflexible	0.08	Curiosity	0.06
Perceived ownership	0.04	Skeptical	0.04
Perceived fear/the uncanny valley	0.04	Trust	0.02
Perceived aesthetics	0.02	Fresh and surprising	0.02
Motivational dimension	Percentage	Horror	0.02
Motivation	0.27	Satisfaction	0.02
Engagement	0.24		

The emotional dimension of service robot implementation, especially their hedonic value, has been the most prevalent dimension discussed in the collected literature. Studies have found that service robots can enhance the hedonic experience (e.g., enjoyment) [2, 10, 32]. The reviewed literature provides significant support for the conclusion that the hedonic experiences afforded by service robots can enhance users' positive attitudes [2, 20], satisfaction [9, 18], and acceptance [8-9]. These results emphasize that in addition to cognitive determinants, emotional factors can also be the driving forces of the adoption of service robots.

Regarding the social aspect of service robots, studies have found that they can promote the connection between customers and the outside world [6, 10, 12, 28], encourage customers to participate in social interaction and value co-creation [6, 10, 23], and have motivational value and social value for customers.

4. DISCUSSION

4.1 Key findings and future opportunities

Firstly, this paper combs the relevant literature on the research methods of service robot. It can be seen that most studies reviewed adopt qualitative methods. In contrast, quantitative methods are relatively less widely adopted. For example, as in van Pinxteren et al. [19] shows, the studies of service robots are scarce and mostly descriptive, illustrating the need for experimental research. This suggests that diversified research methods may help to bring more enlightenment on service robots.

Secondly, this paper points out that the service robot has three technological characteristics: physical embodiment, social interaction, and data-driven design. The inconsistent understanding of the relationship between anthropomorphic robots and customer attitude [24, 25] and the limitations of service robots' intelligence and autonomy [23] need to be addressed in future research. We hope that more research will focus on the links and effects between the technological characteristics of service robots and provide conclusive findings. This would bring new context-specific insights and provide important guidelines for harnessing the power of service robots.

Thirdly, there are still gaps between consumers' expectations and actual service outcomes. Service providers need to know more about customers' practical needs to innovate effectively. Customers' reviews would be an interesting way to improve service robots' design and functionality. At the same time, current research focuses more on the positive outcomes of service robot use, emphasizing the potential for value co-creation, while less attention has been paid to the possible negative impacts and the possibilities of value co-destruction, which should be improved in the future.

4.2 Implications

This work makes four contributions: first, as far as we know, this is the first systematic review to explore the participation of service robots in service delivery. Second, this paper analyzes the technological characteristics of service robots, on which there is currently no consensus among existing studies. Third, we sort out the positive and negative outcomes of service robot use from cognitional, emotional, motivational and social dimensions. Finally, the research consolidated in this paper provides some insights that enterprises can use in deploying service robots. The research results of this paper will enable scholars in related fields to have a deeper understanding of service robots and their characteristics, enable managers to clearly understand more application scenarios of service robots and the possible positive or negative service outcomes of their participation in the service delivery process. To harness the power of these robots, it is important to understand their technological characteristics and effects, and this need is especially critical and timely for practitioners considering robotic deployment in their operations [17].

4.3 Limitation

An important limitation of this study is the limited scope of the literature we collected, which only met our selection criteria. For instance, we only consider studies of service robots participating in service delivery in service contexts. By enlarging the pool of articles, future literature review studies may elicit more insights about service robots.

5. CONCLUSIONS

This study provides an overview of the literature on the role and effects of service robots in service delivery. Based on a review of 28 papers, we report on how and where service robots have been employed, what technological characteristics of service robots have been commonly analyzed, and what potential service outcomes service robots may have. The findings of this review indicate that due to their high-tech capabilities, service robots are characterized by three technological aspects: physical embodiment, social interaction, and

data-driven design. The cognitional, motivational, social and emotional aspects of these robots, and their service delivery can have positive or negative outcomes on the customer experience. The research conclusions of this paper will have some enlightenment to the academic and practical circles.

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REFERENCES

[1] Wirtz J, Patterson P G, Kunz W H, Gruber T, Lu V N, Paluch S, Martins A (2018). Brave new world: Service robots in the frontline. Journal of Service Management, 29(5): 907-931.

[2] Kabadayi S, Ali F, Choi H, Joosten H, Lu C (2019). Smart service experience in hospitality and tourism services a conceptualization and future research agenda. Journal of Service Management, 30(3): 326-348.

[3] Chiang A H, Trimi S (2020). Impacts of service robots on service quality. Service Business, 14(3): 439-459.

[4] Ivanov S, Gretzel U, Berezina K, Sigala M, Webster C (2019). Progress on robotics in hospitality and tourism: A review of the literature. Journal of Hospitality and Tourism Technology, 10(4): 489-521.

[5] Kuo C M, Chen L C, Tseng C Y (2017). Investigating an innovative service with hospitality robots. International Journal of Contemporary Hospitality Management, 29(5): 1305-1321.

[6] Caic M, Mahr D, Oderkerken-Schroder G (2019). Value of social robots in services: Social cognition perspective. Journal of Services Marketing, 33(4): 463-478.

[7] Qiu H L, Li M L, Shu B Y, Bai B (2020). Enhancing hospitality experience with service robots: The mediating role of rapport building. Journal of Hospitality Marketing & Management, 29(3): 247-268.

[8] Gursoy D, Chi O H, Lu L, Nunkoo R (2019). Consumers acceptance of artificially intelligent (ai) device use in service delivery. International Journal of Information Management, 49: 157-169.

[9] Xiao L, Kumar V (2019). Robotics for customer service: A useful complement or an ultimate substitute? Journal of Service Research, forthcoming.

[10] Chen Y, Wu F, Shuai W, Chen X (2017). Robots serve humans in public places—kejia robot as a shopping assistant. International Journal of Advanced Robotic Systems, 14(3): 1-20.

[11] Caic M, Odekerken-Schroder G, Mahr D (2018). Service robots: Value co-creation and co-destruction in elderly care networks. Journal of Service Management, 29(2): 178-205.

[12] Portugal D, Alvito P, Christodoulou E, Samaras G, Dias J (2018). A study on the deployment of a service robot in an elderly care center. International Journal of Social Robotics, 11(2): 317-341.

[13] Kitchenham B (2004). Procedures for performing systematic reviews. Keele, UK, Keele University, 33: 1–26.

[14] Brereton P, Kitchenham B A, Budgen D, Turner M, Khalil M (2007). Lessons from applying the systematic literature review process within the software engineering domain. Journal of Systems and Software, 80(4): 571–583.

[15] Xu Q L, Ng J S L, Tan O Y, Huang Z Y (2015). Needs and attitudes of singaporeans towards home service robots: A multi-generational perspective. Universal Access in the Information Society, 14(4): 477-486.

[16] Jorling M, Bohm R, Paluch S (2019). Service robots: Drivers of perceived responsibility for service outcomes. Journal of Service Research, 22(4): 404-420.

[17] Tung V W S, Au N M (2018). Exploring customer experiences with robotics in hospitality. International Journal of Contemporary Hospitality Management, 30(7): 2680-2697.

[18] van Doorn J, Mende M, Noble S M, Hulland J, Ostrom A L, Grewal D, Petersen J A (2017). Domo arigato mr. Roboto: Emergence of automated social presence in organizational frontlines and customers' service experiences. Journal of

Service Research, 20(1): 43-58.

[19] van Pinxteren M M E, Wetzels R W H, Ruger J, Pluymaekers M, Wetzels M (2019). Trust in humanoid robots: Implications for services marketing. Journal of Services Marketing, 33(4): 507-518.

[20] Tuisku O, Pekkarinen S, Hennala L, Melkas H (2019). Robots do not replace a nurse with a beating heart. Information Technology & People, 32(1): 47-67.

[21] Tung V W S, Law R (2017). The potential for tourism and hospitality experience research in human-robot interactions. International Journal of Contemporary Hospitality Management, 29(10): 2498-2513.

[22] Khaksar S M S, Slade B, Wallace J, Gurinder K (2019). Critical success factors for application of social robots in special developmental schools. International Journal of Educational Management, 34(4): 677-696.

[23] Pinillos R, Marcos S, Feliz R, Zalama E, Gomez-Garcia-Bermejo J (2016). Long-term assessment of a service robot in a hotel environment. Robotics and Autonomous Systems, 79: 40-57.

[24] Mende M, Scott M L, van Doorn J, Grewal D, Shanks I (2019). Service robots rising: How humanoid robots influence service experiences and elicit compensatory consumer responses. Journal of Marketing Research, 56(4): 535-556.

[25] Turja T, Aaltonen I, Taipale S, Oksanen A (2020). Robot acceptance model for care (ram-care): A principled approach to the intention to use care robots. Information & Management, 57(5): 103220.

[26] Belanche D, Casaló L V, Flavián C (2019). Artificial intelligence in fintech: Understanding robo-advisors adoption among customers. Industrial Management & Data Systems, 119(7): 1411-1430.

[27] Dautenhahn K (1998). The art of designing socially intelligent agents: Science, fiction, and the human in the loop. Applied Artificial Intelligence, 12(7-8): 573-617.

[28] Khaksar S M S, Shahmehr F S, Khosla R, Chu M T (2017). Dynamic capabilities in aged care service innovation: The role of social assistive technologies and consumer-directed care strategy. Journal of Services Marketing, 31(7): 745-759.

[29] Li J (2015). The benefit of being physically present: A survey of experimental works comparing copresent robots, telepresent robots and virtual agents. International Journal of Human-Computer Studies, 77: 23-37.

[30] Fong T, Nourbakhsh I, Dautenhahn K (2003). A survey of socially interactive robots. Robotics and Autonomous Systems, 42(3-4): 143-166.

[31] Lee K M, Jung Y, Kim J, Kim S R (2006). Are physically embodied social agents better than disembodied social agents?: The effects of physical embodiment, tactile interaction, and people's loneliness in human–robot interaction. International Journal of Human-Computer Studies, 64(10): 962-973.

[32] Zhang T, Kaber D B, Zhu B W, Swangnetr M, Mosaly P, Hodge L (2010). Service robot feature design effects on user perceptions and emotional responses. Intelligent Service Robotics, 3(2): 73-88.

[33] Riikkinen M, Saarijarvi H, Sarlin P, Lahteenmaki I (2018). Using artificial intelligence to create value in insurance. International Journal of Bank Marketing, 36(6): 1145-1168.