Saputra, F., Buhalis, D., Augustyn, M., Marangos, S., 2024, Anthropomorphism-based Artificial Intelligence Robots in Hospitality and Tourism, Journal of Hospitality and Tourism Technology.

Abstract

Purpose

Anthropomorphism plays a crucial role in the deployment of human-like robots in hospitality and tourism. This study proposes an anthropomorphism-based typology of AI robots, based on robot attributes, usage, function, and application across different operational levels.

Design/methodology/approach

Following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) checklist, the research was conducted in two stages. A search strategy was implemented to explore anthropomorphism-based AI robots and to develop a robot typology.

Findings

This study provides a comprehensive typology of anthropomorphism-based AI robots used in tourism and hospitality and classifies them into four types, namely: chatbots, mechanoids, humanoids, and android robots. Each type features distinct functions and applications.

Practical implications

The findings can assist companies in using anthropomorphic robots to improve service and strengthen competitiveness. The study offers valuable insights to managers for deploying AI robots across diverse service sectors.

Originality/value

This research provides a novel typology of hospitality and tourism AI robots and extends the understanding of anthropomorphism in human-robot interaction. This typology encompasses both virtual and physical robots, providing clarity on their attributes, usage, functions, and applications across diverse areas of hospitality operations.

Keywords - Anthropomorphism, AI Robots, Hospitality
Paper type – Exploratory Research and Literature Review

1. INTRODUCTION, state-of-the-art, and objective

Robots have extensive contributions across industries. In tourism and hospitality, robots revolutionize guest experience (Pizam *et al.*, 2022; Pizam *et al.*, 2023; Huang *et al.*, 2021; Kim *et al.*, 2023). The convergence of cutting-edge technologies, such as chatbots, artificial intelligence (AI), and robotics, is transforming the tourism and hospitality landscape (Buhalis *et al.*, 2019, Bulchand-Gidumal, et al 2023). Human touch and personalized service are critical elements in delivering exceptional experiences. The integration of robots into service represents a significant shift in both processes and mindset. Ivanov and Webster (2023) explored preferences for robots in restaurants, whilst Ivanov *et al.* (2020) explained hotel managers' perceptions towards the use of robots. Robot integration presents challenges, including: replacement for human roles (Zlotowski *et al.*, 2015); undermining human-centric hospitality values (Choi *et al.*, 2020); information security (Pizam *et al.*, 2024); managers adoption (Pizam *et al.*, 2022); customer adoption (Ozturk *et al.*, 2023); and creating unique experience (Fuste-Forne, 2021). Understanding the robot's attributes and contribution to service experience is imperative for robot adoption (Seyitoglu and Ivanov, 2020; Ivanov *et al.*, 2023). Robots' attributes, such as appearance, emotions, traits, and behaviour, determine adoption and human interactions.

Anthropomorphism is fundamental for human-robot interaction (Song and Kim, 2022). It extends beyond robots' physical appearances and delves into how their traits and behaviours influence individuals' tendencies to perceive them as human-like (Zlotowski *et al.*, 2015; Song *et al.*, 2024). Anthropomorphism influences how people perceive, interact with, and accept robots (Akdim *et al.*, 2023; Jia *et al.*, 2021) and highlights the human-like traits exhibited by robots (Tussyadiah *et al.*, 2020). Kim *et al.* (2022) and Wirtz *et al.* (2018) underscore the importance of aligning robots' capabilities with their intended tasks. The literature demonstrates a gap in the classification of hospitality and tourism anthropomorphic AI robots. The rapid usage of anthropomorphic AI robots requires a structured typology to support research development and help businesses align robot types with specific tasks and customer needs. Therefore, this research aims to synthesize knowledge and establish a well-defined typology of anthropomorphism-based AI Robots to support adoption strategies for all stakeholders.

2. LITERATURE REVIEW: Anthropomorphism-based AI Robots

2.1. Defining Anthropomorphism-based AI Robots

Anthropomorphism helps us understand how humans perceive objects with human-like characteristics. Anthropomorphism finds application across diverse domains, encompassing: products (Baskentli *et al.*, 2023; Velasco *et al.*, 2021); brands (Sharma and Rahman, 2022); advertising (Lee and Oh, 2021); and non-human entities, like robots (Song and Kim, 2022; Yam *et al.*, 2021b). Mori (1970) first examined people's reactions to robots that closely resembled humans in appearance and behaviour. Scholars have proposed various definitions of anthropomorphism, as detailed in Table 1.

Table 1. Definitions of Anthropomorphism

Leading literature	Definitions
Mori (1970)	Anthropomorphism can be decomposed into the effects of appearance and behaviour since they both interdependently influence human-robot interaction.
Guthrie (1995)	Anthropomorphism refers to the individual tendency to perceive inanimate objects as humanlike entities, and it pervades human judgment.
Keeley (2004)	Anthropomorphism refers to the fact that a product bears human appearance which includes psychological features (e.g., emotions, personalities, gestures) and non-psychological features such as the presence of physical resemblance to human bodies (e.g., head, eyes, arms, legs).
Bartneck *et al.* (2007)	Anthropomorphism refers to the attribution of a human form, human characteristics, or human behaviour to non-human things such as robots, computers, and animals.
Epley *et al.* (2007)	Anthropomorphism refers to the attribution of human characteristics or traits to nonhuman agents.
Waytz *et al.* (2014)	Anthropomorphism is the human tendency to assign human capabilities, such as rational thought and feelings, to inanimate objects such as robots.
Airenti (2018)	Anthropomorphism is the process of attributing humanlike motivations, emotions, or characteristics to real or imagined non-human entities.
Song *et al.* (2024)	Anthropomorphism is the assignment of human traits or actions to nonhuman objects,

The common thread among these anthropomorphism definitions lies in attributing human characteristics, emotions, or behaviours to non-human entities, such as animals, objects, robots, or natural phenomena. Epley *et al.* (2007) and Epley (2018) suggest that anthropomorphism is not solely related to human-like appearance, but also encompasses other mental capacities that resemble humans, such as emotions, behaviour, and relational qualities. This study synthesizes these definitions to suggest:

> *Anthropomorphism-based AI robots are defined as: artificial intelligence-powered robots that are imbued with human-like attributes, encompassing physical appearances, emotions, behaviours, and relational qualities*.

This definition reaffirms what characteristics AI robots must possess to closely resemble humans. By endowing intelligent robots with human-like features, users accept and utilize these robots more readily. Personification, through human traits, facilitates customers in forming a positive perception of robots (Kuhne and Peter, 2023). The application of anthropomorphism extends beyond physical robots, to include virtual entities, such as chatbots and virtual assistants (Buhalis and Moldavska, 2022, Wirtz *et al.*, 2018). Robot anthropomorphism "positively affects perceived warmth and competence affecting guests' word of mouth and continuous usage intention, while perceived competence only positively influences guests' continuous usage intention" (Song *et al.* 2024). However, "Uncanny Valley" suggests that while people like things with human-like features, there is a point where too much resemblance can evoke discomfort (Bartneck *et al.*, 2007). Mori *et al.* (2012) emphasized that for service robots, visual resemblance to humans is not enough; they must also perform tasks like humans. This distinction is vital because industrial robots prioritize function over appearance, unlike toy or service robots. Hence, hospitality robots must resemble both humans and perform tasks akin to human capabilities (Bartneck *et al.*, 2007).

2.2. Key theories related to anthropomorphism

Researchers studying anthropomorphic AI robots use a range of human-robot interaction theories. These are often combined with other theoretical frameworks (Table 2). For example, Lin *et al.* (2020), Zhang *et al.* (2021), Cui and Zhong (2023), and Alsaad (2023) employed the Artificially Intelligent Device Use Acceptance (AIDUA) theory to examine the attributes incorporated into robot design. Other studies connect Human-Robot Interaction (HRI) and anthropomorphism with various other theories, including: cognitive appraisal theory, the technology acceptance model, mind perception theories, and social cognition theory (Lu *et al.,* 2021, Said *et al.* 2023, Yam *et al.* 2021b, Yoganathan *et al.* 2021). Lin *et al.* (2020) and Zhang *et al.* (2021) determined the extent to which consumers accept or prefer human-like attributes in a robot and explored correlations with other factors influencing the interaction experience with robots.

Table 2. Key theories related to anthropomorphism

Theory	Key Works	Essence	Relevance to Anthropomorphic AI Robots
Artificially Intelligent Device Use Acceptance (AIDUA) theory	Gursoy *et al.* (2019)	This theory explicitly explains consumers' intention to accept using AI devices in service delivery. The AIDUA model elucidates the multistep process by which consumers decide whether to use an AI device during a service encounter.	The AIDUA theory explains the factors that influence consumer acceptance of artificially intelligent devices. These factors include anthropomorphism, performance expectancy, effort expectancy, and emotional dimensions.
Uncanny Valley Theory	Mori (1970)	Uncanny Valley Theory suggests a nonlinear relationship between the perceived human likeness of robots and their likability. As robots become more similar to humans, their familiarity and likability tend to increase at first. However, once a robot's appearance becomes nearly human-like but not quite perfect, it can elicit feelings of uneasiness and discomfort in those who observe it.	Understanding and navigating the Uncanny Valley are crucial in designing and implementing anthropomorphic robots to ensure positive user experiences and acceptance.
The Technology Acceptance Model (TAM)	Davis (1989); Venkatesh and Davis (2000)	The Technology Acceptance Model (TAM) is a widely recognized theoretical framework that explains and predicts users' acceptance and adoption of new information technologies. It focuses on two primary factors: perceived usefulness and perceived ease of use, which influence users' attitudes and intentions regarding the use of a technology.	The Technology Acceptance Model (TAM) provides a valuable framework for studying users' acceptance of anthropomorphic robots in various applications, including hospitality. By incorporating TAM, researchers can assess how users perceive the usefulness and ease of use of anthropomorphic robots, which are essential factors in determining users' attitudes and intentions toward interacting with these robots
Social Cognition Theory	Fiske *et al.* (2007)	Social cognition theory involves the cognitive processes related to perceiving, interpreting, and responding to social information about oneself and others. It includes	The concept of anthropomorphism can be better understood by exploring social cognition theories. These theories focus on the psychological factors, motivations,

Theory	Key Works	Essence	Relevance to Anthropomorphic AI Robots
		the identification and comprehension of socially relevant cues like emotions, intentions, and behaviours, which are essential for effective social interactions.	and social needs that drive individuals to attribute human traits to non-human entities.
Mind Perception Theories	Gray *et al.* (2007); Gray and Wegner (2012); Yam *et al.* (2021)	The Mind Perception Theories suggest that both human and nonhuman entities are perceived along two dimensions: agency (which refers to the ability to think, plan, and act volitionally) and experience (which pertains to the ability to feel emotions, pain, and pleasure).	In the realm of anthropomorphic robots, The Mind Perception Theories are significant as they delve into how users attribute mental capacities to nonhuman entities, such as robots.
Cognitive Appraisal Theory	Lazarus (1991)	The Cognitive Appraisal Theory (CAT) is centered on the evaluation and response of individuals to various situations, depending on their cognitive appraisals. These appraisals, in turn, shape their emotional and behavioral reactions.	By applying Cognitive Appraisal Theory (CAT), researchers can analyze how users evaluate the anthropomorphic characteristics of robots, such as their appearance, behaviour, and communication style. They can then examine these appraisals to determine their influence on users' trust, anxiety, and overall acceptance of the robots.

Anthropomorphism offers a vast area for research from various perspectives and dimensions. It intersects with theories in psychology, social sciences, engineering, anthropology, marketing, tourism, and hospitality. These theories support a comprehensive understanding of how psychological, cognitive, and social factors impact the acceptance, likeability, and interaction with anthropomorphic robots. By integrating insights from these theories, researchers can gain a better grasp of the complexities of human-robot interactions and develop anthropomorphic robots.

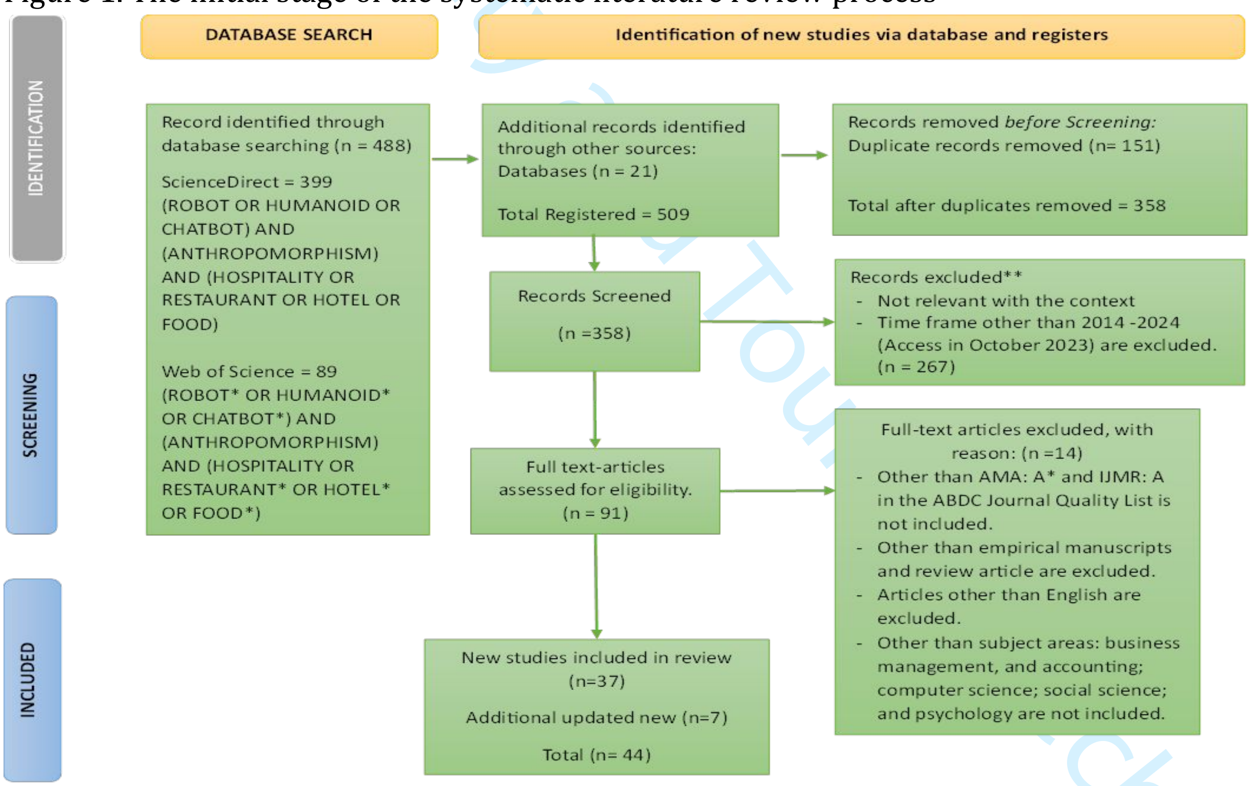
3. METHODOLOGY

A systematic literature review aims to answer specific research questions using a systematic and explicit methodology to identify, select, and critically evaluate the results of the studies included in the literature review (Rother, 2007; Hiebl, 2021). It requires literature searching and retrieval, data analysis and synthesis, and the ability to write and report findings following a step-by-step guide (Cronin *et al.* 2008). This study followed the step-by-step guidance outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist.

After establishing the rationale and objectives, the next stage involved determining the inclusion and exclusion criteria. The data collection process followed the four stages proposed by Moher *et al.* (2010) to ensure transparency, rigor, and reproducibility. These stages include identifying keywords and databases, selecting and screening relevant papers, assessing and verifying relevant articles, and analyzing the selected studies. A search strategy was implemented using two major databases (Web of Science and ScienceDirect) to identify research on anthropomorphism in AI robots within hospitality. Keywords such as (ROBOT* OR HUMANOID* OR CHATBOT*) AND (ANTHROPOMORPHISM) AND (HOSPITALITY OR RESTAURANT* OR HOTEL* OR FOOD*) were used to gather relevant data.

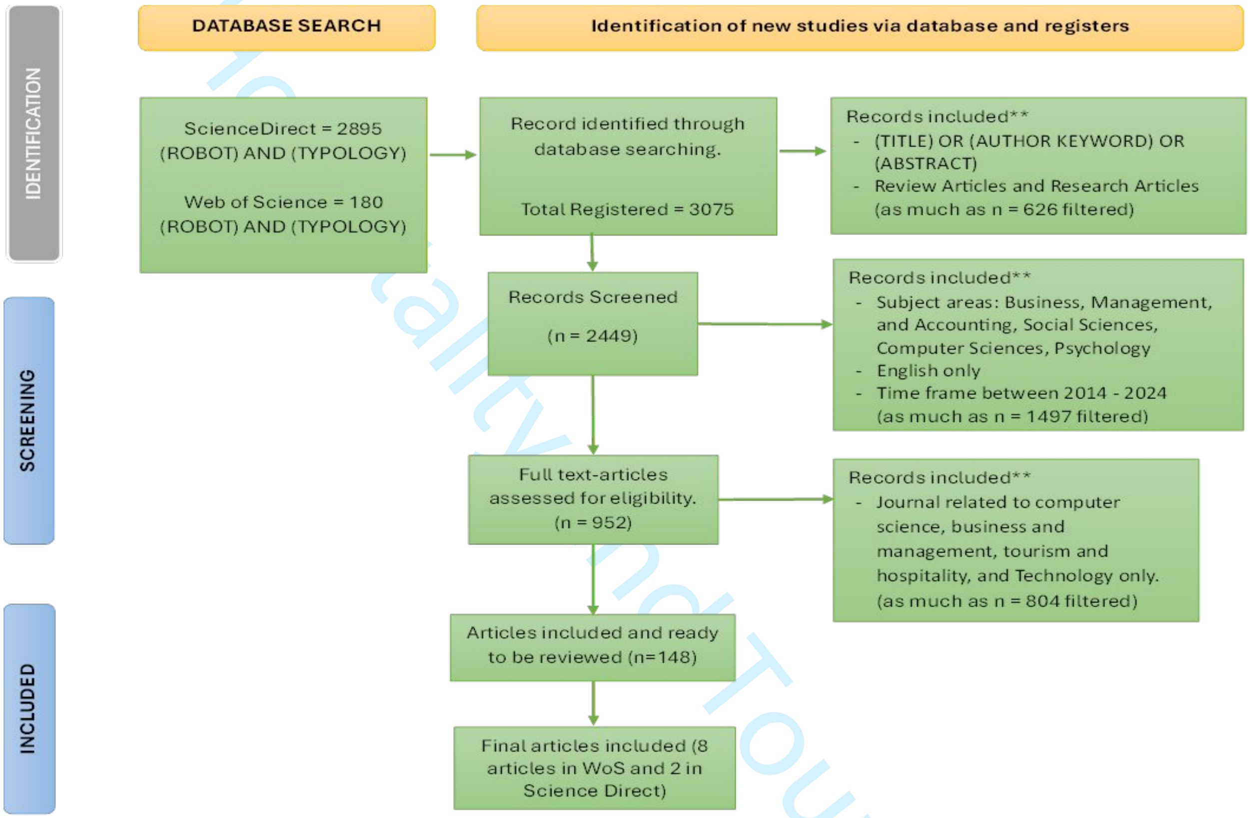
A total of 509 articles were obtained [89 from Web of Science, 399 from ScienceDirect, and 21 from other relevant sources]. A duplicate filter was applied since the study used two extensive databases. Duplicate articles (151) were identified and removed, resulting in 358 unique articles. To refine the results, inclusion and exclusion criteria were applied and the study focused on journals ranked AMA: A*; and IJMR: A in the ABDC Journal Quality List. Journal filtering focused on the most prominent and highly cited outlets (Hiebl, 2021). The criteria for inclusion were limited to review and research articles in the fields of Business, Management, Accounting, Social Sciences, Computer Sciences, and Psychology; written in English and published between 2014 and 2024. Filtering by year was conducted because studies on service robots in the tourism and hospitality industry started in 2014; when the use of service robots began in 2014, at the Aloft Hotel in Cupertino, USA, and the Quantum of the Seas Royal Caribbean Cruise Ship followed by the Henn-na Hotel in 2015. These criteria yielded 37 articles whilst an additional 7 articles from highly ranked journals were included (Figure 1).

Figure 1. The initial stage of the systematic literature review process



A second systematic literature review involved evaluating research and comparing studies on typologies (Figure 2). The keywords "TYPOLOGY" and "ROBOT" generated 180 articles on the Web of Science (WoS) and 2,895 articles on ScienceDirect. Inclusion and exclusion criteria filtered the results, targeting only review and research articles. This reduced articles to 76 in WoS and 2,373 in ScienceDirect. Further subject filtering retained Business, Management, Accounting, Social Sciences, Computer Science, and Psychology articles, published in English between 2014 and 2024. The final inclusion criterion was to include journals specifically related to computer science, business and management, tourism and hospitality, and technology. This process yielded 148 articles, 23 from Web of Science (WoS) and 125 from ScienceDirect. The authors conducted a collaborative discussion to eliminate any irrelevant articles. ScienceDirect contained only 2 articles and WoS had 8 articles that reviewed robot typology (Table 3).

Figure 2. The second stage of the systematic literature review process



4. FINDINGS: Anthropomorphic AI Robots in Tourism and Hospitality

4.1. Robot Typologies Across Industries

The search for "robots" and "typology" illustrated that AI robots can be classified into two primary categories: software-based and hardware-based (Table 3). Research falls short of capturing AI robot typologies in the hospitality and tourism field, illustrating the necessity for further investigation (Schepers and Streukens, 2022; Calero-Sanz *et al.*, 2022). The advancement of anthropomorphic AI robots in terms of their appearance, roles, functions, and characteristics requires research to fill this gap.

Software-based robots encompass virtual assistants and chatbots, while hardware-based robots include those with a physical presence, whether human-like or non-human-like. Gkinko and Elbanna (2023) explored typologies of software-based AI robots, specifically chatbots. Niben *et al.* (2022) approached chatbots as social actors, emphasizing the significance of time in social interactions and highlighting specific goals for conversations based on chatbots' time-dependent design aspects. Hoyer *et al.* (2020) examined new technologies, both software and hardware, such as the Internet of Things (IoT), Augmented Reality (AR), Virtual Reality (VR), Mixed Reality, virtual assistants, chatbots, and robots. They focused on understanding how technologies contribute to the customer journey and created a new typology of AI-powered technologies.

Seven studies on hardware-based AI robot typology from various dimensions and perspectives illustrated four focused on tourism/ hospitality and two healthcare typologies. The tourism/hospitality studies explored robot typologies based on their service area role (Schepers and Streukens, 2022; Go *et al*., 2020; Calero-Sanz *et al*., 2022), as well as on the function of the robot (Orea-Giner *et al*., 2022). Schepers and Streukens (2022) combined theory and practice-driven approaches to propose three distinct roles for service robots: functional, information-sharing, and social-emotional. They also introduced three new safety-related role extensions: safety supervisor, safety informer, and safety social enabler.

Table 3. Robot Typologies in Various Industries

Author(s)	**Context**	**Methodology**	**Theoretical Lens**	**Proposed Typology**
Niben *et al.* (2022)	Chatbots	a mixed-methods research approach	Human-computer interaction and computer-mediated communication	Three time-dependent chatbot design archetypes: Ad-hoc Supporters, Temporary Assistants, and Persistent Companions
Schepers and Streukens (2022)	Service Robots	a combination of a theory- and practice-driven approach	Hierarchy of needs theory, evolutionary human motives theory, perceived risk theory, regulatory focus theory, job demand–resources theory, and theory of artificial intelligence job replacement	Three different service robot roles from past literature (functional, information sharing, and social-emotional) and three new safety-related role extensions (safety supervisor, safety informer, safety social enabler) are proposed
Go *et al.* (2020)	AI robots	reviews current cases of AI use and technology acceptance model (TAM) studies	Technology acceptance model (TAM) and interactive technology acceptance model	This study categorizes AI robots by their main tasks or current roles in the tourism and hospitality industry: communication robot, chef robot, delivery robot, entertainment robot, housekeeping robot, guide robot and security robot
Zafari and Koeszegi (2018)	autonomous artificial agents	a conceptual approach	Agency theory	Non-AI marginally autonomous agents, AI marginally autonomous agents, AI semi-autonomous agents, and AI pseudo-autonomous agents
Henkel *et al.* (2020)	social robots for consumer well-being	a conceptual approach	Service research, social robotics,	A typology of robotic transformative service (i.e. entertainer, social enabler,

Author(s)	Context	Methodology	Theoretical Lens	Proposed Typology
			social psychology, and medicine	mentor, and friend) as a function of consumers' state of social isolation, well-being focus and robot capabilities
Caic *et al.* (2018)	Socially assistive robots	a qualitative, interpretative study	The value co-creation/ destruction, Value network	The proposed typology identifies six roles of socially assistive robots in an elderly person's value network (enabler, intruder, ally, replacement, extended self, and deactivator) and links them to three health-supporting functions by robots: safeguarding, social contact, and cognitive support
Hoyer *et al.* (2020)	New Technologies	a conceptual paper	Experiential Value	Discussing the impact and implications of these technologies on each broad stage of the shopping journey (pre-transaction, transaction, and post-transaction) and advancing a new conceptualization for managing these new AI technologies along customer experience dimensions to create experiential value
Calero-Sanz *et al.* (2022)	Service Robots	an exploratory analysis	Human-robot interaction	The typologies of robots: room service robots, restaurant's robot chefs and robotic bartenders, cloakroom robots, and front-desk robot receptionist and concierge robots. The typology of traveler: business, solo family, couple, and friends.
Orea-Giner *et al.* (2022)	Robot in Hotel	107,663 online TripAdvisor reviews	Human-Robot interaction	The robots' functional typologies and traveller categories

4.2. Anthropomorphic AI Robots in Tourism and Hospitality

Categorizing AI robots into a typology (Table 4) enhances the understanding, effective design, and informed decision-making regarding their adoption (Jia *et al.*, 2021). It also explores their uses, functions, and applications and provides insights and practical value (Xie and Lei, 2022). This study identifies two main categories of anthropomorphic AI hospitality/tourism robots: virtual and physical. Four distinct categories are proposed, namely: chatbot, mechanoid, humanoid, and android robots (Table 4).

Virtual robots are software-driven and engage with users through text or voice, employing natural language (Roy and Naidoo, 2021). Chatbots, including Amazon Alexa, Apple's Siri, Google Assistant, and Microsoft''s Cortana, interact with humans via text or voice inputs (Klein and Martinez, 2023). Chatbots are virtual robots, characterized by anthropomorphized human-like traits (Klein and Martinez, 2023). In hospitality, chatbots fulfill numerous roles, from information search, customer service, travel tips, booking, and reservations (Zhang *et al*., 2024). While chatbots dominate virtual robots, anthropomorphism refers primarily to physical robots.

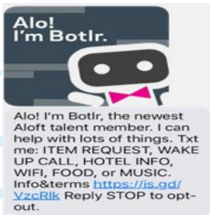
Physical robots require hardware, are tangible and often perform physical tasks (Akdim *et al*., 2023; Kang *et al*., 2023). Alabed *et al*. (2022) emphasized that physical robots are commonly distinguished based on appearance, influencing their tasks. Kang *et al*. (2023) classified physical robots into machine-like, semi-human-like, and human-like service robots. A machine-like service robot lacks human characteristics or appearance and typically features articulated hydraulic arms. A semi-human-like service robot resembles a hybrid of humans and robots, with a cartoon-style face and metal skin. A human-like service robot is the most anthropomorphic, exhibiting human-like features such as hair, eyebrows, eyes, nose, ears, mouth, arms, hands, and legs.

Jia *et al*. (2021) describe anthropomorphism in terms of low, medium, and high levels. Mechanoid robots, which use mechanical bodies to perform specific tasks, fall into the low level. AI robots can range from partially human-like to highly human-like. Partially human-like robots, often referred to as humanoid or semi-human-like, have a medium human-like appearance (Akdim *et al*., 2023; Alabed *et al*., 2022; Huang and Liu, 2022; Kim *et al*., 2022; Kim *et al*., 2023). Highly human-like robots, known as androids or realistic robots, are smart, intelligent, and autonomous entities (Akdim *et al*., 2023; Xie and Lei, 2022). In this study, physical robots are classified into three categories: mechanoids, humanoids, and androids. Based on these classifications, the development of a unified typology of AI robots in the hospitality industry is essential to address these issues.

4.2.1 Virtual Robot – Chatbots

The widespread use of chatbots in various areas of service operation is due to their contribution to increasing efficiency, scalability, and user experiences. Chatbots are used across various areas. In hospitality, they help with answering questions, booking reservations, and suggesting places to eat or visit. The companies get benefits from chatbots in automating conversations, facilitating reservations, operating 24/7, providing instant responses to user messages and inquiries, and offering multilingual support across communication channels. Chatbots serve as AI virtual assistants, reservation agents, inbound reservation CRM tools, and omnichannel inboxes for hotels, enabling seamless integration across various platforms.

Table 4. Anthropomorphic AI Tourism/Hospitality Robots Typology

	Virtual Robots	Physical Robots		
	Chatbots	Mechanoids	Humanoids	Android Robots
Real Example				
Classifications	Chatbots, short for chat robots, are computer programs designed to simulate human speech in interactions facilitated by digital interfaces.	Mechanoids are a type of physical robot equipped with mechanical bodies and specific functions aimed at improving guest services and operational efficiencies across various service sectors.	Humanoids are physical robots designed to resemble humans to some extent, with features such as a head, facial expressions, arms, and legs, intended to enhance guest service experiences.	Android or Realistic robots represent a specialized category of physical robotics engineered to closely resemble human features and behaviour, aiming to achieve a striking level of similarity to real humans
Features	• Human-like avatar • Unique personality • Varying autonomy levels • Communication features (names, voice, language) • Mimicking human conversation • Enhancing natural interaction • Providing a human-like experience	• Predominantly machine-like. • Operate independently or without supervision. • Prefer non-verbal interaction. • Programmed with specific behaviours for tasks. • Recognize and respond to social cues.	• Resemble humans physically to some extent. • Operate with different levels of autonomy. • Generate behaviours like facial expressions and head movements autonomously. • Autonomously perform behaviours, including communication and physical actions.	• Closely mimic actual humans • Commonly considered autonomous. • Multifaceted communication styles. • natural and adaptable behaviour.
Usage	• Automating chats • Assisting with reservations • operating 24/7 • Offering quick responses to messages • Answering user inquiries • Making bookings • Recommending places to eat or visit	• Carrying materials • Handle a multitude of tasks. • Handling repetitive and labour-intensive tasks. • Reducing human staff workload. • Freeing up staff for more complex or guest-focused activities.	• Assisting guests with questions, directions, or needs. • Ensuring quick and efficient service. • Programming enables personalized interactions. • Recognizing and responding to individual guest preferences or past interactions.	• Programmed to act like humans. • Commonly used for entertainment, reception, research, and customer service. • Recognizing and responding to individual guest preferences or past interactions.
Functions	• Increasing efficiency • Increasing scalability • Ability to enhance user experiences	• Improve efficiency. • Reduce costs. • Enhance guest experiences	• Improve efficiency. • Reduce costs. • Enhance guest experiences	• Enhance guest satisfaction and experiences
Applications	• AI virtual assistants • Booking agents • Reservation management tools • Omnichannel inboxes for hotels • Enabling seamless integration across various platforms	• Room service delivery. • Waiting service • Cleaning robots • Maintenance duties • Concierge services • Applying both front-of-house and back-of-house tasks	• Customer service. • Information provision. • Room service. • Housekeeping. • Concierge services. • Entertainment.	• Entertainment • Customer service. • Information provision. • Concierge services. • Demonstration • Entertainment.

Designing chatbots with anthropomorphic features to enhance human-likeness is on the rise. A key challenge with chatbots is their lack of physical presence during interactions. People expect human-like attributes in interactions, even without physical presence (Epley, 2018; Epley *et al.*, 2007). Automated social presence is becoming more relevant as companies increasingly replace human service personnel with automated service robots. By considering these factors, organizations can strategically deploy chatbots to elevate customer experiences and streamline operational efficiency in hospitality settings.

4.2.2 Mechanoid Robots

Mechanoids are physical robots equipped with mechanical bodies that perform specific functions aimed at improving guest services and operational efficiencies (Figure 3). Mechanoids are recognized for their resemblance to machines, rather than humans, distinguishing them from human-like robots. These robots are programmed to sense, interact with, and assist customers, representing a significant advancement in the integration of AI and robotics to perform specific tasks without invoking the uncanny valley effect (Zhang *et al.*, 2021). This provides opportunities for touchless interactions and improved services.

Figure 3. Examples of mechanoid robots

Picture Source: Pudu Robotics (https://www.pudurobotics.com/)

Mechanoids are the primary type of physical robots widely employed across different areas of the hospitality industry due to their efficiency. A significant rise in the utilization of hospitality AI mechanoid robots is driven by businesses striving to enhance operational efficiency, cut costs, and elevate guest experiences. (Akdim *et al.*, 2023; Said *et al.*, 2023). By taking on repetitive and labour-intensive tasks, mechanoids alleviate the human workload, allowing staff to deal with complex guest-centric activities in front-of-house and back-of-house tasks. Front-of-house applications encompass welcoming guests, offering assistance or directions, and facilitating in-room amenities delivery. Back-of-house tasks encompass inventory management, facility cleaning and maintenance, and logistical operations. Mechanoids may be more prevalent in specific hospitality settings where human-like features are not deemed essential.

4.2.3 Humanoid Robots

Humanoid robots have human-like traits but are still recognized as robots (Figure 4). These robots are designed to mimic human-like appearance and behaviour, influencing human perception and interaction (Huang and Liu, 2022). The design of humanoid robots plays a crucial role in their acceptance and effectiveness in social interactions. Studying how the appearance of humanoid robots affects human behaviours is crucial for optimizing human-robot interactions (Tung and Au, 2018). They have a physical appearance that resembles humans to some extent, with features such as head, facial expressions, arms, and legs (Said *et al.*, 2023). The capabilities and interactions of humanoid robots are often influenced by the varying levels of autonomy at which they operate.

Figure 4. Examples of humanoid robots produced by various manufacturing companies

Picture Sources: [01]Alpha robotics Co., Ltd. (https://www.alpharobotics.com.cn/); [02,03]Aldebaran (https://www.aldebaran.com/)

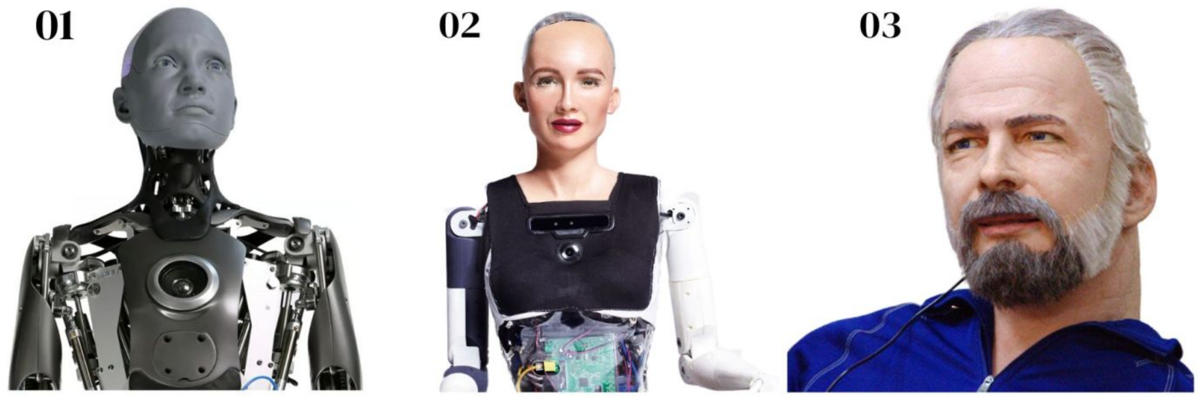
Humanoids are the second most common physical robot type in hospitality, following mechanoids. Research demonstrated that both mechanoid and humanoid robots influence user comfort levels, as well as their acceptance and willingness to engage, particularly when compared to Androids (Akdim *et al.*, 2023). Humanoids are increasingly popular due to their human-like appearance and potential for engaging in interactions with customers.

The prevalence of robot types in hospitality settings is shaped by factors such as cost-effectiveness, functionality, and user acceptance (Gursoy *et al.*, 2019; Lin *et al.*, 2020; Said *et al.*, 2023; Song and Kim, 2022; Zhang *et al.*, 2021). Across various service operations, humanoid robots are integrated into diverse tasks, ranging from customer service, housekeeping, restaurant servers or assistants, facilitating tasks such as food delivery and table cleaning (Ivanov and Webster, 2023).

4.2.4 Android Robots

Android or realistic robots are physically engineered to closely resemble human features and behaviour, aiming to achieve a striking level of similarity to real humans (Figure 5). Android robot design depends on their intended functionality and interaction with humans. They are the most advanced due to their close resemblance to humans, including facial features and expressions, limbs, emotional manifestations, expressions, social interaction capabilities and behavioural characteristics. These robots are crafted not only to replicate human appearance but also to simulate human movement and behaviour; thereby blurring the traditional boundaries between machines and humans (Jia *et al.*, 2021). The design and appearance of android robots influence how guests perceive them.

Figure 5. Examples of Android robots produced by various manufacturing companies



Picture Sources: [01]Engineered Arts - Ameca (https://www.engineeredarts.co.uk/robot/ameca/); [02,03]Hanson Robotics (https://www.hansonrobotics.com/).

Despite their potential, android robots have not seen widespread adoption in the hospitality industry yet; mainly due to the investment required to purchase the hardware and train the robot. Customers may find highly android robots unsettling or discomforting, posing challenges to their acceptance and integration within hospitality environments. This reluctance can also be attributed to the uncanny valley phenomenon and negative customer perceptions. Because these robots appear so human-like, guests may expect them to perform as well as humans, leading to disappointment if they fall short. This significantly impacts the hesitancy to embrace Android robots in service-oriented settings (Bartneck *et al.*, 2007; Yam *et al.*, 2021). Designers should consider natural and adaptive behaviour in Android robots, to enhance the overall guest experience. A noteworthy example is Ameca, known as the Aura Robot in the Las Vegas Sphere; a Humanoid Robot That Interacts with Guests [A short video demonstration can be watched on Youtube https://youtu.be/QNTSDEBMVXg]. Aura enhances the visitor experience by combining entertainment, cutting-edge technology, and human-robot communications, within the immersive Las Vegas Sphere Entertainment experience. Another real-world application of android robots is the Henn-na Hotel Sasebo in Nagasaki, Japan, which embraced such robots nearly a decade ago. However, the company soon realized that robots could not wholly replace human employees and dismissed half of their robotic workforce as they inadvertently damaged customer experience and created more work for humans (Gale and Mochizuki, 2019). Developing and maintaining android robots is complex and expensive, which can be a barrier for the hospitality industry to employ them in operations. As a result, companies may prefer simpler and cheaper robot options.

5. Discussion and Conclusion

5.1 Conclusion

Exploring the application of AI robots in hospitality yields insights into their acceptance and integration within service environments (Pizam *et al.*, 2022; Pizam *et al.*, 2023). Examining AI robot attributes and applications underscores their potential to enhance guest experience and operational efficiency, inspiring innovative applications and enabling businesses to uncover new opportunities for leveraging this technology to enhance service delivery. This study provides a comprehensive classification of anthropomorphism-based AI robots into four distinct types, namely: chatbots, mechanoids, humanoids, and androids.

Anthropomorphism is adopted in this study to explain the different typologies of robots in the hospitality industry. This categorization is useful to explore the different types of robots, by defining characteristics, exploring unique features, and functions, and examining models and applications across various hospitality elements. By matching the level of anthropomorphism to the task, robots can be designed to perform specific functions more effectively. These different types of robots guide the development of appropriate regulatory standards and ethical guidelines to ensure that robots are used safely and responsibly.

5.2 Theoretical implication

The proposed typology provides insights into the adoption of anthropomorphic robots and their potential in hospitality service delivery. This research illuminates the intricate relationship between technological advances and the evolving dynamics of service delivery, clarifying the possible roles and contributions of robots. By exploring the typology of robots, the study reveals a variety of capabilities and applications, providing valuable insights into their potential contributions. Analyzing the specific characteristics of AI robots that are relevant to their adoption in hospitality services provides essential information. A comprehensive understanding of the unique benefits, functions, and applications of different types of hospitality robots is critical to elucidating their proliferation and potential impact on customer experience and operational efficiency.

5.3 Practical implication

Categorizing service robots according to their roles and functions offers a promising strategy for streamlining service tasks across hospitality. This approach empowers businesses to integrate anthropomorphic robots into their operations to improve operational efficiency and heighten customer satisfaction levels. It enables businesses to efficiently fulfill designated service roles and illuminate the various functions robots can perform to enhance both guest experiences and operational efficiency.

The results also show that mechanoid and humanoid robots are more likely to be used in hospitality services than androids. Companies need to know where to put their money in investing in robots. Besides the need to adjust the business ecosystem, companies also need to ensure that they can create a proper working environment that supports multiple interactions between robot-consumer, and robot-employee, as well as cooperation between human-robots. The use of human-like robots (android robots) also raises social and ethical issues that may hinder their integration into hospitality operations, which is essentially a human industry that requires emotional intelligence.

5.4 Limitation and future research

Although the current study offers several important implications, some limitations should be considered for future research. First, future research should aim to broaden the scope to more thoroughly examine the typology of service robots in different business settings. Research focusing on user perspectives should guide successful implementation by identifying barriers and facilitators to effective use. The development of a comprehensive typology of service robots serves as a cornerstone for fostering consumer adoption and intent. Improving service quality, ensuring seamless interaction, and optimizing operational tasks will largely depend on the seamless integration of robots in diverse industrial service environments. A comparative analysis with existing robot typologies in manufacturing, distribution, and other industries or contexts would highlight opportunities for cross-fertilization of processes and innovations across industries.

Second, the future development of robots poses challenges for researchers that are consistent with the dynamic nature of robotics research. The uncanny valley phenomenon (Mori, 1970; Mori et al., 2012), a concern for many developers and hospitality businesses, may come under scrutiny as robotics technology advances and the digital native generation grows. This evolving landscape is likely to create new contexts that can serve as fertile ground for future research agendas.

Third, while anthropomorphism theory derived from psychological studies can independently explain why people attribute human characteristics to robots, it becomes significantly more powerful when integrated with other theories in the context of behavioral and social interaction research. Combining anthropomorphism theory with behavior theory, human cognitive theory, human-computer interaction (HCI), human-robot interaction (HRI), mind perception theory, and technology acceptance theory, among others, enhances our understanding of these phenomena, depending on the research context. The identified robot typologies can be used to explore other phenomena, such as AI ethics, privacy issues, psychological anthropomorphism, and socially interactive robots, as well as to inform consumer market segmentation.

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