



Evaluating the Co-dependence and Co-existence between Religion and Robots: Past, Present and Insights on the Future

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Accepted: 19 February 2020
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Abstract

The relationship between religions and science can be considered historically controversial in nature. In constantly evolving global societies, it is important to provide a new perspective on the past and present relationship between religions and technological developments in the different societies. In this regard, this paper will provide insights into the different ways in which ancient societies and their religious traditions helped in the development of technological progress. At one end, it will highlight some of the positive contributions of different religions towards technological progress in the past. At the other end, this discussion will aid in dispelling the viewpoint that perceived the ancient cultures and societies as bereft of technological knowledge and innovation. This paper will provide a historical perspective on the development of relationship between religion and robotics in the past. A brief look at the existing scenario within the contemporary societies will also be examined, along with discussion of socio-cultural norms and values related to perception of robots in different Eastern and Western cultures. The discussion will conclude with some predictions regarding the future, along with the different ways in which the relationship of co-existence and co-dependence is expected to evolve between religion and robotics in the future, which goes beyond the predictions of mass annihilation and mass enslavement by sentient AI-based robots.

Keywords Religion · Robotics · Social robots · Artificial intelligence (AI) · Automaton · Humanoid robots · Roboethics

1 Introduction

Throughout the human existence, religions have played a central role within the different societies in the past. However, there has not been sufficient research concerning the inter-relationship between Religions and Robots that can link the present development in science, technology, and innovation. This particular emphasis will be in relation to development of artificial intelligence (AI), machine learning (ML) and Robotics in the broader historical, sociocultural and religious context of the civilizations of the past. The literature sources of the past (ranging from Greek and Roman stories regarding mechanical contraptions and automatons to modern-day classical literature such as Shelley's [1] *Frankenstein*) and contemporary media sources (ranging from Asimov's [2] *I, Robot* to mass media portrayals in movies and televi-

sion series such as *Dark Mirror*) that focus on the different issues surrounding the evolution and increased usage of AI-based applications and robots within the modern societies. The purpose of this discussion is to shed light on the inherent fascination of the human civilizations throughout history with the development of self-sufficient, autonomous technologies. It is for this reason that the present Robotic revolution can be effectively viewed as a continuation of the inherent human to develop machinations with human-like intelligence, autonomy and cognitive capabilities. At the same time, in light of the positive historical perspective between religion and technological innovations, a number of potential recommendations will be provided towards maintaining a mutually-beneficial religion-robotics relationship in the future.

For the purpose of discussion in this research related to AI, it is important to provide some distinctions. There has not been a single widely-accepted definition of the word 'artificial intelligence' within the research community. According to the *International Dictionary of AI* [3], AI is the field concerned with developing techniques that allow computer systems to act in a manner that is similar to an intelligent

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organism, such as a human being. Whereas, Nilsson [4] defined AI as any activity that is required to enhance the intelligence of machines, which can allow these machines to work in accordance with their intended functions and environmental factors. In this paper, definition provided by Nilsson [4] will be used as reference for AI-based systems. Theoretically, the range of intelligence of artificial systems can vary considerably from providing improved performance within a particular application (formally termed as weak AI) to sentient systems that are able to demonstrate human-level intelligence within a broad-range of activities and applications (termed as strong AI). Currently, the discussion related to AI in this paper will primarily focus towards weak AI systems, as strong AI systems are still not considered a practical reality within the current research community.

The topic of Religion and Robotics has received little attention in the past. Some studies have been published in recent years, which have attempted to address some of the underlying issues within the scope of Religion and Robotics. A recent study by Loffler [5] examined the feasibility of deploying religious robots in the German context with an overall positive response from different respondents who interacted with two robots. Unlike [5], this research provides a broad-level historical discussion regarding some of the positive aspects of the relationship between religion and technological developments in the past, present and the near-future. Weng et al. [6] discussed the impact of Taoism towards the development of ethically-focused development in the field of Robotics. In comparison with [6], this research has a broader scope in terms of discussing the impact of diverging religious traditions in a historical perspective.

Another recent research examined the practical and design feature requirements for religious robots to enhance the overall experiences of the religious devotees [7]. Although, the negative experiences between religions and technological innovations, particularly the middle age christian inquisition are frequently discussed in various forums (e.g., Church reaction to Galileo's heliocentric view of the solar system). The latter research [7] confirms the hypothesis that examines religion and technological innovation as two 'extreme' paradigms. However, unlike [7], the purpose of this study is to provide a non-confrontational historical perspective on religion and robotics, along with exploration of the potential to further develop the positive inter-relationship. In order to accomplish that, this study will examine the numerous positive contributions of the different religions towards furthering the envelope of technological innovation (particularly related to robots and automations) in the past. In this research, the prime focus will be towards the positive evidences related to the inter-relationship between different religions and technological development in the past. In this respect, this research will further the discussion regarding the ways in which reli-

gions and robotics can co-exist and collaborate within the different Eastern and Western societies.

The development of this research required searching and collection of a wide-range of relevant research from a number of different reliable peer-review research forums, namely *IEEE Xplore*, *SpringerLink*, *Google Scholar*, and *ScienceDirect*. The different keywords used to search for relevant literature for the different elements being highlighted in this research include "religion and robotics," "history of religion and robotics," and "cultural acceptance of robotics". In order to ensure that only the most relevant studies were included in this research, the search was restricted to include papers published after 1st January, 2000. Exceptions to this rule were made for the different researches mentioning the automata and technological innovation in the earlier civilizations, specifically in connection with religion. The following section will discuss the earliest evidences in the literature regarding the co-dependence and inter-relationship between religion and robots (here, this term will be interchangeably used to refer to prehistoric automata as well as modern-day social robots and related technologies, depending on the context of the underlying discussion).

2 Religion and Robotics: A Historical Overview

Religion and robotics have a long tradition of relative harmonious co-existence in the past. The purpose of this section is to explore the historical origins of robots, which encompass all mechanical contraptions, automata and other devices developed to mimic nature and human beings in terms of their diverging range of independence of thought, cognitive capabilities and autonomy. This discussion will also shed light on some of the positive aspects of the inter-relationship between religions and technological development over the ages; a perspective, which is not sufficiently highlighted in the relevant literature. Despite history of conflicting viewpoints between theologians and scientists in the past, particularly in the European Middle Ages, it can be reported that there are numerous examples in human history that are filled with evidences to support the lasting alliance between technological innovation (here referred to mechanization, automata and robots) and different religious traditions. The recent scholarship has facilitated in dispelling the myths surrounding the *technical blocage* (the antiquated literary viewpoint that promoted the technological backwardness of the Ancient cultures and societies) of ancient civilizations [8, 9]. In a similar manner, it is important to re-examine the relationship between religion and technology, in particular robotics, automata, and mechanical contraptions of the past in a critical and unbiased fashion.

2.1 Brief History of Robots and their Development

It is difficult to pin-point the earliest instances of mechanical devices and automata developed by the early human civilizations. While, the current knowledge in this regard has survived in the form of literary and historical accounts as well as mechanical models of devices in ancient texts. It has been an age-old desire of human beings to animate the inanimate, and to ‘breathe life’ into the lifeless. The evidences of ancient rock and cave paintings, as well as dolls and figurines are testaments to this fact [10]. The earlier civilizations like the Greeks, along with their writers and poets were fascinated with the image of entities that could do human’s bidding in an autonomous way, such as statues that suddenly appeared life-like in nature, Hephaestus’ tripods that were able to function with a degree of mobility, and golden attendants that were gifted with a higher degree of functionality and independence of thought, behavior and cognition [11–13]. These automata were a “wonder to behold” (p. 124) for human beings, as the mere thought of creations other than themselves capable of independent thought and physical autonomy has fascinated mankind for centuries [14]. Homer’s *Odyssey* recounts of devices or ancient technologies, which allowed Phaeacian ships to navigate without steers and sailors; this can be taken as one of the earliest accounts of an ancient AI in historic texts that could navigate accurately, even in unfavorable weather conditions [15]. There is more to ancient Greek automata and mechanical devices than mere fables and fiction, as the discovery of *Antikythera Mechanism* has revealed with its intricate gear mechanisms, which has been hailed as one of the earliest man-made mechanical calculators used for predicting the location of five planets over time [10]. Heron of Alexandria’s designs and drawings of various ancient mechanical devices and automata have also survived up till present day [8]. Generally regarded as nothing more than ‘toys’, recent studies have shown that if reconstructed, these devices will fulfill their original purposes for which they were designed [16, 17].

Similar to the Greeks, the Roman literature also highlighted the trend of fascination with automata continuing with mentions of Mechanical Theater; a set of weight-driven mechanical puppet theaters [18] and the origination of the *Metamorphoses* myth and *Pygmalion* in the literary work created by Ovid [19]. The Romans were also able to transform lifeless figurines into automata that provided entertainment for the masses and filled people with wonder and inspiration [10]. Contrary to earlier belief, the antiquated civilizations, such as Greeks and Romans, were far more advanced in terms of technology than previously anticipated [7, 8, 20], while many of the automata and their modern reconstructions have shown that they are capable of demonstrating the desired behavior mentioned in the ancient texts [16]. Despite the association of the term ‘robot’ with mod-

ern electro-mechanical devices, the automata developed by ancient mechanics, engineers and artists, such as Heron and Hephaestus have been described using the term ‘robot’ in the past [21–23].

It was not until the Renaissance that Europe was able to showcase an array of impressive automata and mechanical devices. Leonardo Da Vinci is one of the many artists and engineers who developed various mechanical devices, automata and military vehicles, which can be classified under the category of ‘robots’ [24]. His automata were admired by many of his compatriots and contemporaries of the time; some of the different mechanical devices and automata mentioned in the various historical texts include *Mechanical Lion*, *Flying Bird* and *Mechanical Knight* [25–27], to name a few. With the developments in mechanics, engineering and technology, efforts were dedicated towards developing highly sophisticated mechanical devices and automata. Another famous automaton of the eighteenth century was the Chess Automaton, also known as the *Mechanical Turk* created by Wolfgang von Kempelen, which toured Europe and North America and amazed the audiences with its human-like intelligence and skills as a chess-master [28, 29]. Although, the authenticity of this robot has been termed as doubtful [30]. However, the level of interest and fame it received in Europe and North America point to the inherent fascination of the Industrial-era Western societies with automata and AI. Some of the other famous designers and engineers with their machines and ‘robots’ include: Pierre Jaquet-Droz and the Writer (a life-like doll in the shape of a human child, which could write text on paper, while all of the mechanical parts were housed within the body of the doll) [31] and Jacques De Vaucanson’s Duck (a highly intricate life-like duck, which similar to Jaquet-Droz’s automata, contained all of the essential mechanisms within the duck’s body that allowed it to eat and digest food, after which the digested food was defecated) [32].

2.2 Brief Historical Overlap between Religion and Robotics

In this section, many of the antiquated relics will be highlighted, which were specifically developed and commissioned by the various technical experts or religious authorities of their times. In similar lines to the previous sub-section, this sub-section will shed light on the primary purpose for which the Greeks and other ancient civilizations utilized the various mechanical contraptions and automata. One of the earliest mentions of robotic machines and automata during the Ancient Greek period include *Automaton Snail* constructed by Demetria of Phaelum, which was used in ceremonial procession of governor Demochares [33], statue of *Nysa* at the Grand Procession capable of pouring libation of milk and wine, typically used for religious ceremonies,

festivals and sporting celebrations [34], the ‘dancing baskets’ at the festival organized at the temple of Artemis [35], and the automatic temple door opening with the sound of trumpets [36], to name a few. Based on the data available from the different accounts, it can be assessed that the temples of gods and goddesses in Ancient Greece were typically equipped with mechanical contraptions and automata (e.g., dancing or revolving figurines, singing or flying birds and self-playing instruments) that attempted to inculcate the aura of supernatural and divine presence, thereby inspiring the followers, producing feelings of fear and wonder, which ultimately increased their religious devotion [16, 17]. In this respect, the religious festivals of the Greek era frequently utilized the awe-inspiring and devotion-instilling elements of mechanical devices and automata to enhance the festivities and religious experiences of the audiences witnessing those spectacles [14]. In this manner, robots and automata have long been used in the religious settings to enliven the spirit and religious teachings in the hearts and minds of the followers, especially at important religious ceremonies and festivals.

Few centuries later, the tradition to use mechanical devices and automata to essentially ‘breathe life’ into religious entities and symbols was also adopted by the Christian Church in the Middle Ages and onwards. This tendency to mobilize mechanical devices in the religious context has been viewed in the following light by Swift [37]:

Robots are gestures towards immortality, created in the face of the undeniable fact and experience of the ongoing decay of our fleshy bodies. Both like and unlike human beings, robots and androids occupy a nebulous perceptual realm between life and death, animation and inanimation (p. 52).

From the earlier days of Christianity, the Church and its teachings have been critical to the development in the various fields of engineering, which includes robotics and automation. The Medieval-era Churches around Europe have been one of the foremost patrons of automata and mechanical devices that were available in a variety of different shapes and performed diverse functions as innovative tools for spreading and strengthening Christianity [38]. It has also been revealed that European Monasteries have played a pivotal role towards translation of ancient seminal works (e.g., Vituvius’ *De Architectura*) and disseminating technological advancements in the fields of mechanical engineering, structural engineering and AI through their application in the development of practical mechanical devices and automata [39, 40]. Some of the most famous religious automata of that time include the following: *La Virgen de los Reyes* from Seville, Spain (mechanical statues of Virgin Mary and young Jesus Christ dating to thirteenth century), *El Cristo de los Casgone* from Segovia, Spain, also dating back to thirteenth

century (mechanical embodiment of Jesus Christ articulated at the shoulders and elbows), *Los Virgen del Valle* from thirteenth century Seville, Spain (full upper torso of Virgin Mary with moveable arms) Athanasius Kircher’s *Resurrection of the Savior* from seventeenth century (automata involving Jesus Christ and Peter in which Christ walks on water to save drowning Peter), mechanical rooster at Strasbourg Cathedral, Germany from fourteenth century, automaton of a praying Franciscan monk in fifteenth century Spain as well as countless manifestations of flying, singing and instrument-playing mechanical angels and demons all across European Churches [37, 38, 41, 42]. Consequently, automata had pervaded into the European society to such an extent that not only did they commonly adorned the religious ceremonies and gatherings, but also the houses of rich aristocracy and royalty [38]. Therefore, it is without any doubt that European Churches were major trendsetters in introducing and spreading the influence of robots from the religious gatherings to secular contexts in European societies. All of the mechanical automata described in this section were designed for fulfilling specific purposes using mechanical components that provided a level of perceived autonomy. In the context of modern AI, these automata cannot be considered as AI-based systems. These automatons could only perform a set of repetitive tasks using mechanical components that provided a perception of autonomy without adaptability. The relationship between religion and robotics will be further evaluated in the proceeding sections, where the focus will be towards the modern-day societies, along with the shifting dynamics between religion and robots.

3 Religion and Robotics in the Contemporary Society

The previous sections of the research have shown how the religion and robots have evolved in a co-dependent manner within the European societies from the ancient Greeks to the Medieval times and the Renaissance period. In the recent times, robots have gained increased importance and utility in various applications, ranging from educational robots [43], to domestic robots for household chores [44] and elderly care [45], social robots for communication and interaction [46] as well as entertainment-based interactive robots for young children and toddlers [47, 48]. It is important to understand that the desire and need to develop artificial entities with some degree of autonomy and intelligence that allow them to assist human beings in their everyday lives can be traced thousands of years back to the earliest mechanical inventions in the Ancient Greek era [49]. The utilization of robots to perform various tasks in independent or co-dependent manner with their human counterparts is no longer a fictional concept, which has led to an in-depth exploration of Human–Robot

Interaction (HRI) in various settings in recent years [46, 50, 51]. However, majority of the discussion is related to the functional, social and cultural aspects of robots [52–55], while the religious sentiments of individuals and the way in which religious values shape the acceptance and perception of robots has not been adequately studied. Furthermore, HRI is a complex phenomenon [56, 57] and future studies in this respect should further explore the various *human-level* (e.g. personal preferences, attitudes, etc.), *robot-level* (perception, action, recognition, etc.) and *interaction-level* (e.g., human-like behavior, timing, quality of interaction, etc.) factors that lead to improved interaction, engagement and overall positive experiences for the human participants.

As, the technology and its applications have improved significantly in the past century, so have the societal, cultural and religious values within the respective societies. Similarly, over time, the perception and acceptance of technology is also expected to change with improvements in level of exposure, training and skillset at the individual and collective, societal level [46, 58, 59]. Societies, their inhabitants, along with their respective socio-economic, political, religious, and cultural values and norms are fluid and in a state of constant dynamism over time. In the modern societies, this apparent fluidity has allowed the blurring of lines and merger between religious and secular teachings, such that the influence of various religious values has spilled over to the secular aspects (e.g., science and technology, robotics, governance, economics, etc.), while various secular norms have also affected the religious teachings and morality in the societies [60, 61]. The benefit of technology can only be realized, if these technological advancements are in harmony, fit and cohesion with the underlying cultural, social and religious foundations of the society [62]. Earlier studies have shown that religious teachings have a significant impact on the overall acceptance and perception of robots, along with their application in the various roles and responsibilities within the societies [63–65]. In the following discussion, emphasis will be towards examining evidences from Eastern and Western societies regarding the adoption and acceptance of robots in general with a particular emphasis on studies related to educational and household robots. The research related to the adoption of religious robots is in its infancy. It is for this reason there will be a need to gain insights from associated research areas, which can aid in the development of religious robots for different societies in the future. Therefore, in the absence of evidence related to religious robots, studies related to robotics in general will be highlighted to gain insight regarding factors affecting acceptance and adoption of robots in different contexts, culminating in the cross-examination of evidences from Eastern and Western societies at the latter part of this section.

3.1 Religion, Robotics and the Eastern Societies

The discussion regarding the perception of robots in contemporary societies will initiate with Japan, which will act as a reference point to analyze the social and cultural aspects in other societies around the world. With regards to exploring the link between religion and robots, Mori [66] has been considered as one of the pioneers, as he allowed for a cohesion between religious teachings of Zen Buddhism and the robots being designed in Japan, which, according to Mori, imbibe the Buddha-nature, similar to human-beings, animals, insects, bacteria and all other forms of life. According to the teachings and philosophy of Zen Buddhism, body and mind are two parts of a greater whole; both essential components in harmony, such that one cannot survive without the other [67, 68]. At the same time, Buddhist belief system and teaching leave considerable room for AI and non-human sentient beings, which makes it easier for them, culturally and socially, to accept and adopt robots than their Western counterparts [69]. Due to their reverence for the physical existence, the beliefs of the Shinto Buddhism put any animated anthropomorphic existence (e.g., humanoid robots) at parallel with human beings [70]. Mori [66] envisioned that in the future, it is very likely that a sentient robot could 1 day, take the place of Buddha as the enlightened one, as “all things have the Buddha nature” (p. 174). The positive religious narrative towards robots is reflected in the overall acceptance of robots in the Japanese society, which include, but is not limited to studies examining the acceptance of robots in the educational context [71, 72], as given in Table 1. The social context of robot usage plays a central role in the acceptance of robots [73, 74]. It is for this reason that Table 1 only discusses studies related to educational robots.

Studies focusing on Japan have outlined a number of different factors impacting the affinity of Japanese people to robots, which include positive Japanese media representation of robots, cultural alignment in relation to Shinto animism as well as collective efforts by industries and government to facilitate the acceptance of robots in the society [54, 62, 70, 75, 76]. Due to the favorable cultural and religious perception of robots in Japan, considerable emphasis is being given towards the development of robots that are human-like in appearance (e.g. Geminoids *HI-2* and *F*) and physiology (e.g., Honda’s *ASIMO*) [77, 78]. A number of studies related to education robot and its adoption and acceptance have been conducted in South Korea [79–82]. In some of the earlier studies, there is skepticism in relation to the idea of robots as teachers [79]. However, the overwhelming body of evidence suggest that use of education robots led to increase in English language skills [81] and enhanced the overall performance, achievement and mental health of students [79, 83]. Study by Yueh and Lin [84] reported variations in the perceptions and preferences of individuals from Taiwan and Japan for

Table 1 Sociocultural acceptance of education robots in the Eastern countries

Study details	Research focus	Study findings
<i>Study Han [79]</i> Country Korea Robots IROBI Sample 30 (Students)	Effect of home educational robot on students' English language learning	Students using educational robots scored higher in terms of achievement, interest and concentration
<i>Study Shin [80]</i> Country Korea Robot Education robots Sample 85 (Students)	The students' interest and perception of robots for education	Majority of the students were not favorable to the idea of robots as teachers
<i>Study Choi [81]</i> Country Korea and Spain Robot Education robots Sample 65/95 (Students)	Cultural acceptance of education robots for students and their parents from Korea and Spain	Korean parents and students had a higher cultural acceptance of education robots than their Spanish counterparts
<i>Study Hashimoto [70]</i> Country Japan Robot SAYA Sample 68 (Students)	The acceptance of robot tutor within the class environment	The elementary students had higher level of acceptance and motivation to learn from robot tutor
<i>Study Park [82]</i> Country Korea Robots ROBOSEM Sample 34 (Students)	The impact of Robot teaching assistant on English language learning of students	The English language skills of students were increased with Robot teaching assistant
<i>Study Keren [86]</i> Country Israel Robots NAO Sample 9 (Students)	Effect of Assistive Robotics on Kindergarten student cognition development and geometric thinking	HRI led to positive effects on learning and engagement of students
<i>Study Tanaka [71]</i> Country Japan Robots NAO Sample 18 (Students)	Effect of introducing care-receiving robot on children's vocabulary learning	Learning-by-teaching robot had positive impact on the vocabulary learning of students
<i>Study Keren [87]</i> Country Israel Robots NAO Sample 17 (Students)	Effect of using robots to improve geometric thinking and metacognition of preschool education	Movement and HRI promote learning with robot-assisted learning environment
<i>Study Park [83]</i> Country Korea Robots Two prototype robots Sample 112 (Students)	Effect of using robot for learning towards improving students' mental health and education outcomes	The use of robots for education had a positive effect on performance and mental health

the case of adoption of home service robots. Another study on Singaporean households, which showed that acceptance of robots was dependent on factors such as robot speed, privacy issues, and types of communication [85]. These studies have shown that apart from evidences related to adoption of robots in Japan, many of the studies have failed to stress on the importance of religious factors and their effects towards adoption and acceptance of the robots within Asian countries belonging to the Far East and South East regions.

In this discussion, the emphasis will be towards exploring evidences from some of the available sources that attempted to explore the adoption and acceptance of robots in the Middle Eastern region of Asia. A number of other studies also highlighted the benefits of assistive robotics for early-education by promoting cognitive development, meta-cognition and geometric thinking of young children in Israel [86, 87]. In this regard, Riek [88] and Mavridis et al. [63]

were able to highlight the importance of religion as a factor determining the acceptance of robots in various roles, such that Muslim respondents had a negative perception regarding using robots in hospitals, and schools for teaching their children. While, Buddhists and Hindus had a comparatively inclusive attitude towards using robots in different settings and contexts [63, 88]. This shows that Japanese cultural and religious values, along with the various societal dynamics provide a unique atmosphere, which promote effective partnership and co-evolution between religion and robotics. The discussion in the next sub-section will highlight the acceptance and adoption of robots within Western societies.

3.2 Religion, Robotics and the Western Societies

Similar to the Japanese society, the Christian faith and its teachings have heavily influenced the development of

Table 2 Sociocultural acceptance of education robots in Western countries

Study details	Research focus	Research findings
<i>Study</i> Mitnik [100] <i>Country</i> Chile <i>Robots</i> Graph Plotter <i>Sample</i> 70 (Students)	The effect of assistive robotics towards facilitating teamwork and learning of geometric concepts	Use of robot enhanced the performance, motivation and collaboration of students
<i>Study</i> Fernandez-Llamas [101] <i>Country</i> Spain <i>Robots</i> Baxter <i>Sample</i> 190 (Students)	Computational competencies of students after being taught by robot teacher	Student with higher age were able to perform better with robot teacher
<i>Study</i> Serholt [106] <i>Country</i> UK/Sweden/Portugal <i>Robots</i> Education robots <i>Sample</i> 77 (Teachers)	Ethical and social implications of introducing education robots on children, teachers and overall learning experience	Teachers are ambivalent towards the effects in relation to students' privacy, and responsibility in case of negative consequences
<i>Study</i> Reich-Stiebert [43] <i>Country</i> Germany <i>Robots</i> Education robots <i>Sample</i> 345 (Students)	Attitude of German students towards educational robots	The respondents preferred one-on-one learning scenarios with the robots in the role of teaching assistant with preference varying across disciplines. Overall, respondents were hesitant to learn from robots
<i>Study</i> Serhold [105] <i>Country</i> Sweden <i>Robots</i> Education robot <i>Sample</i> 45 (Students)	The perception of students towards usage of education robots	Robot were perceived as tools, not social agents. Robots were viewed in assistive role, not as replacement to human teachers
<i>Study</i> Serhold [107] <i>Country</i> Sweden, UK <i>Robots</i> Education robots <i>Sample</i> 8 (Teachers)	The perception of teachers towards usage of education robots	Overall cautious attitude of teachers towards adoption of robots in education has been demonstrated in this study. Teachers were fine with using robots as assistants, as long as they were efficient
<i>Study</i> Brown [102] <i>Country</i> USA <i>Robots</i> DARWIN <i>Sample</i> 44 (Students)	Effect of using robot on students' performance	Using robot for verbal engagement minimized idle time and increased performance of the students
<i>Study</i> Walker [103] <i>Country</i> US <i>Robots</i> LEGO NXT + iPod Touch <i>Sample</i> 37 (Students)	Social affordance and its impact towards student learning and social perception of robot	Students with robots demonstrated small improvements in learning gains
<i>Study</i> Kennedy [117] <i>Country</i> UK <i>Robots</i> NAO <i>Sample</i> 87 (Teachers)	Perception of general public and teachers towards the use of education robots	General public has a more positive outlook on use of education robots than educators. Using robots as tools in education is preferred
<i>Study</i> Pinto [104] <i>Country</i> Brazil <i>Robots</i> NAO <i>Sample</i> 30 (Students)	Level of Interaction and Engagement (Low–High) by the robot tutor	The students with high-level of engagement and interaction performed better than low interaction group

Robotics in the Western side of the world. As, previous section has focused on the role of Church towards the popularity of mechanical contraptions and automata for propagating the religious teachings in Europe and other regions. However, unlike their Eastern counterparts (i.e. Shinto and Zen Buddhism), monotheistic religions, such as Christianity, Judaism and Islam have a strict classification between living and non-living things, where the former have a soul, while the latter do not, which means that the non-living objects, such as robots cannot take a position of moral equivalence [89, 90]. Therefore, Western societies and their inhabitants' viewpoint

towards interaction with intelligent and sentient artificial beings is linked with fear and amazement [48, 91, 92].

The feelings of amazement and fear are resonated in the general acceptance of robots in the Western societies. The use of social robots in a wide-range of environments and contexts has been discussed in recent studies. For example, the feasibility of using robots as second language tutors was examined by Belpaeme et al. [93]. Similarly, a number of studies have evaluated the acceptance of social robots in school settings [94, 95], robots as assistants in surgical procedures [96] and robots for elderly daily-assisted living [49, 97]. Study by [90] reiterated the importance of religion

for acceptance and adoption of robots. Research on social robot in hospital located at Austria revealed considerable social acceptance by the resident staff [55]. Another research in Finland pertaining to inclusion of social assistive elderly care robots in household environment also revealed generally positive attitude of respondents, which highlights social and cultural inclusion of robots [98]. Previous studies from Germany associated with different applications of robots (e.g., educational robots, domestic robots) also revealed positive attitude and perception of robots [43, 99].

The use of robots in education has received considerable attention in the past. From the students' perspective, studies

have demonstrated that use of robots in varying roles (e.g., robot as teaching assistant or as tool for engagement) has led to improved students' academic performance, reducing idle time and increased engagement in classrooms in different Western countries [100–104]. It is interesting to note that most of the European students view robots as educational tools, not as social agents or replacements for human teachers [43, 105]. The details of the different studies related to educational robots are highlighted in Table 2. However, parents and teachers are concerned regarding potential implications of using robots in classrooms for students [81, 106, 107]. For the acceptance and adoption of robots in the household settings,

Table 3 Acceptance of domestic robots

Study details	Influential factors	Overall attitude
Study Xu [85] Location Singapore Robots Home service robots Sample 30	Robot speed, communication type, privacy, user acceptance	The attitude and acceptance reduced after practical demonstration with the robot
Study Fink [59] Location Switzerland Robots Roomba Sample 30	Practical usefulness, environment context, ease of use, compatibility with routine, attachment, social and economic compatibility	Personal attitudes and household environment plays a critical role in the acceptance and adoption of robots. Robot viewed as tool, not social agent
Study Sung [108] Location US Robots Roomba Sample 42	Physical and social space, social actors and their perception over time Tasks being performed	The perception changed from viewing robot as utilitarian tool to a social agent with identity assignment (name, gender and personality) Technical issues limit long-term adoption and acceptance
Study de Graaf [110] Location Netherlands Robots Karotz ambient electronic device Sample 102	<i>Attitudinal beliefs</i> usefulness, ease of use, social presence, sociability <i>Normative beliefs</i> social influence, media influence, image, trust, societal impact <i>Control beliefs</i> self-efficacy, anxiety towards robots, cost <i>Outcomes</i> use attitude, use intention, actual use	Past experiences, usefulness, social presence, enjoyment, expectation gaps, clearer purpose of usage affected the perception and acceptance of robot over time
Study Alaiad [109] Location US Robots Home healthcare robots Sample 108	Performance expectancy, social influence, privacy and ethical concerns, effort expectancy, trust	Social influence and privacy issues are of paramount importance for acceptance and adoption of home healthcare robots
Study de Graaf [46] Location Netherlands Robots Karotz zoomorphic robot Sample 6	<i>Utilitarian factors</i> usefulness, ease of use, adaptability, intelligence <i>Hedonistic factors</i> enjoyment, attractiveness, anthropomorphism, sociability <i>Usage context</i> social influence, privacy, trust, prior experiences and expectations <i>User-level factors</i> age, gender, type of household	Overall positive response of elderly towards the robot with increased needs and expectations for social interactions over time
Study Li [111] Location China/US Robots Domestic service robots Sample 435/301	<i>Contextual factors</i> social and physical environment <i>Cultural factors</i> face, dignity, honor	The need for developing complex normative reasoning to understand cultural norms and the contextual factors
Study de Graaf [73] Location Netherlands Robots Domestic robots Sample 1,168	Social influence, social status, self-efficacy, anxiety towards robots, safety costs	Normative beliefs have increased effect on the acceptance of social robots in domestic setting. Many people are reluctant for robots to demonstrate social behavior

a number of studies have been conducted in the different Western countries. Due to the different frameworks utilized for assessing technology adoption, a wide range of different factors have been highlighted, ranging from past experiences, personal attitudes, perceived usefulness to socio-cultural factors, social perception, entertainment, technical issues and underlying limitations of the robots [46, 59, 73, 108–111]. In the following sub-section, a comparison and cross-evaluation of the studies related to robot acceptance and adoption in Eastern and Western societies will be discussed.

3.3 Cross-Cultural Attitudes and Perception of Robots

Previous sub-sections have primarily dealt with the religious aspects and robotics in different Eastern and Western societies. This section will compare and contrast between the sociocultural attitudes and perceptions of the different Eastern and Western societies regarding the use of robots in varying contexts. The religious beliefs have substantial influence towards shaping the social sentiments of individuals in societies [90]. It is for this reason that highlighting the sociocultural attitudes and perceptions of people around the world will allow the examination of the relationship between religions and robots in contemporary societies from a different dimension. Due to the deeply-intertwined nature of the social and religious elements within any society, correlation between the sociocultural and religious sentiments can be considered as a norm. Religion can be considered as one of the enabling factors, which facilitate the spread of robots in the Japanese society [69, 74]. For example, the religious philosophies and teachings of Zen Buddhism have helped in shaping the development of robots and facilitated the acceptance of robots in Japan to an extent [66, 112]. Evers et al. [113] revealed that national culture is another factor, which in their study, affected the acceptance and perception of robots by highlighting divergences in opinions between US and Chinese individuals. Another study by Li et al. [114] revealed two other factors impacting the acceptance of robots, namely national cultures and perceived tasks being performed by robots (e.g., using robots as teacher, guide, security guard or entertainment tool). With respect to the Western societies, some of the national-level factors that impact the acceptance of robots include media portrayal, prior experiences, perceived behavioral control, anthropomorphism, usefulness, sociability and enjoyment [114, 115]. Another study examining the variations in the acceptance of robots between students from Italy and UK revealed that British students had lower perceived usefulness and intention to use for social robots. Whereas, the Italian students demonstrated a higher perceived usefulness and intention to use [65]. This shows that there are various national- and cultural-level factors, which affect the perception and acceptance

of robots differently across the different Western countries (Table 3).

A cross-cultural examination in relation to the acceptance and perception of robots was discussed by Nomura et al. [54]. It was revealed that respondents from Western (i.e., UK) societies harbored negative perception and attitudes regarding humanoid robots in comparison with their Eastern (i.e., Japan) counterparts [54]. Unlike Japanese respondents, the perceived fears and negative attitudes harbored by Western individuals was age-dependent in nature [116]. For the usage of education robots in the Western societies, most of the students showed affinity towards robots in assistive roles without replacing the human teachers [105]. However, teachers were concerned regarding the potential negative implications of using robots on the students [106, 107, 117]. In contrast to the evidences from the Western societies, education robots have relatively higher acceptance in the Eastern societies [70, 71, 79–83, 86, 87]. However, similar to Western societies, Xu [85] showed that the attitude and acceptance of many of the Singaporean households decreased over time. A similar study exploring the usage of robots in domestic settings by Taiwanese people revealed that it might be some years before widespread usage of social robots in Taiwan can be considered as a norm [84]. Generally, people from the Middle Eastern countries (e.g., Saudi Arabia, United Arab Emirates) are cautious towards the utilization of robots in specific domains (e.g., healthcare and children education) [63, 88]. Their cautionary attitude towards robots stem from the cultural and religious values, as even though Islam does not forbid scientific development, technological innovations or robots specifically, but the manner in which robots are being used (e.g., robots as teachers, robots as assistants, robots as entertainment, etc.) require religious assessment and approval [118]. It is for this reason most of the respondents were against the use of robots for teaching their children [63]. These findings correlate with results reported by European Commission Report [119], which showed that majority (86%) of the people were uncomfortable, even in Europe, with the concept of a robot taking care of their children, along with proposing bans towards using robots for elderly care, disabled individuals and children.

4 Future of Religion and Robotics

The future is unpredictable and unforeseeable. Yet, this has not stopped the humans from prophesizing and hypothesizing about the future. However, when the future involves robots and super-human AI entities, there have been sufficient discussions regarding the possible series of events and scenarios that can play out, ranging from mass-extinction to mass-en enslavement of human race [120, 121]. In the presence of

super-human intelligent AI entities, there is no way to predict the future as highlighted by Kacyznski [122]:

First let us postulate that the computer scientists succeed in developing intelligent machines... In that case, presumably all work will be done by vast, highly organized systems of machines and no human effort will be necessary ... if the machines are permitted to make all their own decisions ... We only point out that the fate of the human race would be at the mercy of the machines (para. 172–173)

A future with the slightest possibility of emergence of human-like or super-human AI entities will lead to theological implications and challenges for the societies [123]. Even without the emergence of a human-like intelligent AI, the threat of robots and AI is real. It is for this reason many of the prominent scientists, technology experts and policy makers have repeatedly warned regarding the potential dangers and harmful implications of the large-scale developments in robotics and AI [124]. There has been considerable discussion in the relevant literature regarding the potential negative consequences of robots and AI in the future [125–129]. Therefore, the purpose of this discussion is to specifically explore ways in which the historical relationship between religions and robots can change in the near future; scenarios that do not necessarily involve destruction or mass extinction of human beings. In order to ensure sustainable and peaceful future with coexistence between robots and religion, some of the ethical and regulatory issues and concerns will also be discussed, which can be faced in the future with a continued tradition of co-existence and co-dependent relationship between religion and robots in the future.

4.1 Changing Dynamics of Religion and Robots in the Future

In the near future, the usage of robots is expected to become commonplace in all aspects of life, from shopping malls, homes and airports to mining operations, deep sea exploration, infrastructure monitoring and evaluation, warfare and inter-planetary travel [130–136]. Therefore, this discussion will shed light on only a handful of issues that can arise in the future that can redefine the relationship between religion and robots in the future. The technological developments are expected to accelerate the integration of robots in the various aspects of an individual's everyday life. One effect of such a development in the future will be the drastic reduction in the employment of human operators in factories, industries and warehouses, human assistants in offices and shops [137, 138]. With increased usage of robots for religions in the future, it would be interesting to see the manner in which the different societies are able to adopt robots to perform different religious duties and responsibilities in the different religious

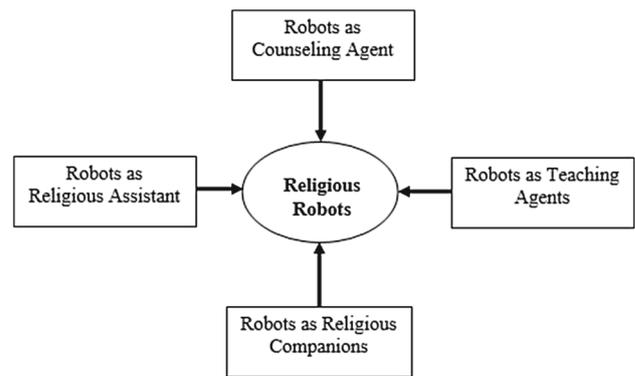


Fig. 1 Different roles that can be performed by religious robots in the future

institutions. At the same time, the effects of such adoption and acceptance in the religious institutions can lead to the emergence of ethical dilemmas in the religious communities.

In the societies of future, the widespread acceptance of robots can give rise to a market for religious robots that cater to the specific needs of different religious devotees (e.g. Christianity, Judaism, Islam, Hinduism, Buddhism, etc.) [139]. Some of the hypothetical roles that can be performed by religious robots in the future are given in Fig. 1, which include the following:

- i. **Robots as teaching agents:** Robots providing knowledge regarding the fundamental teachings of the religious faiths. Social robots used in educational settings (e.g. *Baxter* [101], *Darwin* [102], *Nao* [104, 117]) can be programmed to provide religious information to devotees. Similarly, religious robots employed in [5] can also be re-programmed to provide the relevant knowledge to religious devotees. Existing robot prototypes are not capable of cognitive and intellectual capabilities for facilitating religious teaching. Improvements in the existing capabilities of social robots (e.g. *Ibn-e-Sina*, *Pepper*, *BlessU2*, *Xia'ner*, *Darumo*) in the future can facilitate the development of robots for teaching religious devotees.
- ii. **Robots as counseling agents:** Similar to religious figureheads in the Christian Church, these robots can interact with people as well as counsel and help them in the light of the Canonical Laws and religious scriptures. Unlike social robots designed for educational and religious settings [5, 100, 101, 105–107], providing counsel to religious devotees require a higher-level of cognitive and problem solving capabilities within the social robot. This cognitive framework would allow the religious robots to leverage insights and knowledge from existing religious scriptures towards addressing contextually-

specific problems of the devotees. Although, existing social robots can be programmed for this role to some limited extent. However, the development of a higher-level of religious understanding within religious robots might necessitate the formulation of religious framework in future research efforts.

- iii. Robots as religious assistants: Robots physically assisting the religious figureheads in the accomplishment of everyday life chores and activities in the Church, synagogues, mosques, and temples. In this category of religious robots, a wide array of anthropomorphic and non-anthropomorphic robots can be utilized to perform different tasks. For example, the fifteenth century Franciscan monk automata could be used for blessing a crowd of religious devotees [42]. *Pepper* is already being used within Buddhist funeral services in Japan [140]. Similarly, for cleaning floors, vacuum robots such as *Roomba* [59] and use of other domestic robots developed for household chores [44] could also be used. Robotic manipulators have also been leveraged within various Hindu religious rituals [141].
- iv. Robots as religious companions: Household robots designed to provide companionship for individuals as well as provide information and demonstration regarding the different aspects of religious teachings and knowledge. These social robots could be programmed to disseminate relevant religious knowledge upon request, which would be incorporated as one component within the overall social companionship framework. Some of the existing commercially-available social robots can be programmed to perform such functionalities, such as *Aldebaran*[®] *Nao*, *Pepper* and other social robots developed for elderly care [45, 49, 97, 98]. *Xia'ner* is a Buddhist monk robot, which is able to provide basic-level religious information to devotees [142]. Similarly, another recent study developed *Darumo* as a religious companion robot for elderly population in China and Japan [143, 144]. The different existing robots (e.g. *Ibn-e-Sina*, *Mindar*) can be further developed to be used as a household religious companion containing valuable knowledge for religious devotees.

In light of the theomorphic design of robots proposed by Trovato et al. [145], care should be taken to incorporate the social, cultural and religious values of the targeted religious group in the development of religious robots. These robots should be programmable in order to store the religious values and personal preferences of the different religious adherents [64]. Based on evidences from educational robots [43, 80, 105, 117], it can be hypothesized that the replacement of human figures with robots in teaching capacity might not be socially accepted in religious contexts. This has been empirically validated, as respondents preferred human religious'

figures over robots due to their authenticity, empathy and benevolence, especially during important religious rituals [5]. Meanwhile, the appropriate features for religious robots vary between different religious and cultural traditions [5]. However, future research in this area will further examine the acceptance of religious robots in the different societies and roles described above.

Other than religious robots, another considerably appealing market is for sex robots, which is expected to change the existing dynamics of human–human relationship as well as the underlying social, religious and moral values within the societies of the future [131, 146]. It is being hypothesized that in the future, it will be a common practice for individuals to have their personal sex robots [146]. A number of studies have discussed the implications of large-scale usage of sex robots in the society, from households to red light districts and escort services [147–150]. At one end, it is being posited that usage of sex robots will lead to further objectification of women [149, 150]. On the other end, it is expected that emotional attachment with sex robots will increase social isolation as well as foster de-sensitivity and lack of empathy in humans, which will make it challenging for individuals to interact or develop and maintain relationships with other human beings in the future [147, 148]. The human communities are the foundation of all religions [151], the development of intimacy and relationship between human beings and robots is expected to fracture the foundations of religious communities around the world, along with redefining the entire social structure and dynamics of the human societies of the future. The topics regarding legalization of marriage between humans and robots are also being debated within certain communities. However, recent studies have shown that the majority of present users of robot sex dolls perceive them more as 'objects' or 'tools' to fulfill their desires rather than as sentient being that should be equipped with intentionality, agency or high level of emotional, cognitive and social capabilities [152, 153].

4.2 Robots of the Future: Regulatory and Ethical Implications

In a future human society with persistent contact, interaction and collaboration between human beings and robots, there is a need to take matters seriously in terms of viewing robots not just as objects, but as sentient AI entities with considerable cognitive, perceptive and decision-making capabilities, along with the potential to harm human beings (e.g., robots developed specifically for warfare purposes, malfunctioning robots). In the future, the overall adoption and acceptance of robots is expected to increase substantially. The purpose of this discussion is to emphasize that similar to other applications of robotics and AI, there is a need to be aware of the various ethical, religious, and socio-cultural implications of

using religious robots. At the same time, there will be a need to develop regulatory measures at the local and global level to minimize the potential negative implications and maximize the benefits of robots in the future.

According to Sharkey [154], one of the major ethical concerns posed by the future of robots is linked with the usage of companion robots for elderly, care robots for children and robots developed for warfare. There has been sufficient discussion regarding the placement of blame and responsibility in case the robots malfunction or cause unintended and irrevocable damages to lives and property [155, 156]. In order to address the various ethical issues surrounding the development of sentient AI-based entities in the future, some of the critical aspects that should be addressed include: (i) preventing misuse of technology, (ii) enabling transparency of robots, which can facilitate assessment of their functionality, and (iii) internal mechanisms should be developed specifically for ethical decision-making in intelligent systems and robots [157, 158]. However, developing ethical decision-making in robots can entail significant unanticipated challenges [159–161]. Meanwhile, some of the ethical recommendations have been proposed for engineers, designers, policy-makers, manufacturers, businesses and users of robots with regards to safety, security, traceability, identifiability and privacy aspects [162].

The issue of malfunctioning robots has received considerable attention in recent years. It is being predicted that with increased adoption of robots for diverse applications (e.g. healthcare, driving, activities involving complex decision-making), the frequency of malfunctioning robots are also expected to increase [163, 164], giving rise to considerable challenges. These challenges include the overall reduction in human responsibility and control, loss in value of human skills, reduced self-determination, and facilitation in the wrong-doing activities that can be disguised as robotic malfunction [165]. There are inherent vulnerabilities within majority of robots and AI-based systems, which increase the risk of malfunctioning and threats related to cyberattacks [166]. In case of robot malfunctioning, the issue of liability has also been frequently discussed [163, 164, 167]. In this respect, the traditional legal system is inadequate, due to unpredictability and presence of causal agency without legal agency [164]. Majority of existing works view robots as commercial products in case of liabilities [163, 168]. A framework for trustworthy AI has been proposed within a recent EU report [169], which include three major components, namely *lawful AI* with development of existing legislation to meet the legal requirements, *ethical AI* that ensures conformance to ethical principles and values, as well as technically and socially *robust AI* components.

Ethical analyses of technologies and their potential usage is one of the most important aspects for highlighting potential issues and the formulation of necessary legal regulations

to ensure safe usage of technological innovations, such as sentient AI robots in the future [170]. Similar to robots developed in other fields, there is a need for caution regarding the ways in which future developments in religious robots could potentially have negative implications on the human users. In order to provide ethical and legal protection to consumers, legal standards should be developed, which can ensure that the religious robots provide accurate information without spreading lies and disinformation regarding religions. In this regard, it is imperative to avoid the ‘Android Fallacy’, i.e. treating robots in a manner similar to humans [171]. In order to accomplish that, there is a need to define robots clearly in legal terms. According to Richards and Smart [171], robots have been defined as “a constructed system that displays both physical and mental agency, but is not alive in the biological sense” (p. 5). An inclusive definition of ‘robot’ has also been outlined by Leenes et al. [172], which is based on the five aspects pertaining to the nature, level of autonomy, range of tasks, operative environment, and human–robot interaction capabilities.

The development of legal framework for religious robots in the future would necessitate a better understanding of secular and religious laws and their effective implementation within different contexts and environments. In contemporary societies, the debate and understanding of religious and secular laws in the public spheres is constantly shifting and evolving in nature [173]. In broad terms, Grotius [174] classified the different types of laws into *religious laws* (the original source of these laws is termed as God, given in the form of religious scriptures, e.g. *Torah* for Jews and *Quran* for Muslims), *natural laws* (the source of these laws is also considered to be divine in nature), and *man-made laws* (laws made by humans to facilitate their day-to-day activities within the different societies). The evolution of human societies from homogenous tightly-knit communities to highly diverse and multi-cultural societies had led to the shift in adherence from religious laws (i.e. laws that cater to group of people that adhere to a particular religion) to secular laws (i.e. laws developed to address the various needs and requirements of all groups of people). The religious laws for a particular religious tradition are acquired from their respective religious scriptures; there is no separation of religious and secular spheres of life within the religious framework, as they (which in this case, refers primarily to Judaism) “encompass all aspects of society and of an individual’s life” (p. 678) [175]. The secularization of laws can be viewed as one of the aftermaths of the Enlightenment movement in Europe, which viewed human rationality as the ultimate source for the development of legal framework, leading to the doctrinal separation of the church and state in the West [176, 177].

The development of legal framework pertaining to technological innovations remains challenging, as it is difficult

to keep pace with the rapidly changing state-of-the-art technologies over time [178]. In order to develop a holistic legal framework with considerable room for catering to technological developments in the future, the regulations should be developed keeping in view the various societal factors, namely socio-cultural norms, laws, market factors, and technological architecture [179]. Instead of redefining laws and regulations that specifically target the robotic advancements of the future, it is much more imperative to assess the robustness and reliability of existing laws towards covering the various developments in technologies over time [178].

5 Conclusion

The human desire to create artificial entities with human-like physical, cognitive and emotional faculties has been well-documented in the relevant literature from different eras. From a historical perspective, religion and technological innovation (in other words, science) have shared a contentious relationship. The purpose of this research is not to ignore or refute the darker elements of this relationship, which have become an integral part of the contemporary debate between Religion and Science, particularly in the West. Instead, this paper attempts to emphasize on the positive aspects of the crucial inter-relationship between religions and technological innovation in the past. The authors are of the viewpoint that by viewing religion and technological innovation from a cooperative, rather than competitive lens, researchers, academics, and religious authorities can learn from the mistakes of the past and pave way for a fruitful and mutually-beneficial relationship between religion and robotics in the future. In this regard, this paper has provided an in-depth examination of the co-dependence of religion and robots over the ages. In the earlier civilizations, Greek and Roman automata were employed in a number of different occasions, such as religious festivals and political celebrations. In the present day, some of the aspects of the inter-relation between robots and religion has been elaborated for the various Eastern and Western societies. A number of potential religious applications of social robots in the future have also been discussed, which can help to forge a lasting alliance between religion and robots in the future. However, many of the robot prototypes are in their initial phases. Consequently, there will be a need for in-depth exploration using longitudinal studies to explore the usefulness and effectiveness of the different religious robots towards promoting religious spirituality over time. The existing prototypes (e.g. *Xia'ner* [142], *Santo* [143, 180, 181], *Mindar* [182]) have limited intelligence capabilities and future research should focus towards improving the AI-related aspects of the religious robots, so that they can be of better use towards serving their respective religious commu-

nities. At the same time, the future studies can also explore the different factors that affect the long-term adoption of religious robots, along with the manner in which these factors differ from the adoption of other non-religious robots (e.g. social robots, educational robots, and household robots).

Acknowledgements This material is based upon work supported by the National Aeronautics and Space Administration (NASA) Grant No. NNX15AI02H under the sub-award No. 18-54, issued through the Nevada NASA Space Grant Consortium for Curriculum Development: Robotics and Big Data Curriculum for Undergraduate and Graduate Students of UNR College of Engineering.

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