From Artificial Intelligence to Artificial Consciousness: An Interior Design Implication

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ABSTRACT

Artificial Intelligence continues to develop rapidly and provokes people to think about Artificial consciousness. Anthropocentric understanding considers consciousness a unique feature of human beings not possessed by other living beings. However, software and hardware development demonstrated the ability to process, analyze, and infer increasingly comprehensive data close to the image of human brain performance. Furthermore, the application of artificial Intelligence to human-friendly objects that can communicate with humans evokes the presence of consciousness within these objects. This paper discusses the presence of artificial consciousness in humanoid robots as an evolutionary continuation of artificial Intelligence. It estimates its implications for architecture, primarily within interior design. Consciousness has a special place in architecture, as it guides Intelligence in engineering and brings it to an abstract level, such as aesthetics. This paper extracts popular information from Internet conversations and theories in pre-existing scientific journals. This paper concludes that the adaptability of both parties and the balance of positions between the two parties in the future will influence the development of interior design approaches that will integrate artificial Intelligence and humans.

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1. INTRODUCTION

Experts predict that in 2045 we will see the phenomenon of singularity in which computer capabilities meet human intellectual abilities [1]. Then, supposed computer technology is applied to human-shaped robots. In that case, the world will witness a new race that has yet to exist on the biological evolutionary tree, composed of materials that we classify as inanimate objects (i.e., metal, plastic). One of the designations for the race is a humanoid robot. Humanoid robots are robots whose figures refer to human figures and can interact with humans, having consciousness and understanding like a human brain process. (See Figure 1). One of the abilities of humanoid robots that make them psychologically close to humans is communication. Humans like to communicate with a figure who can respond to their actions, creating a sense of equal footing, even with other species (for example, pets). The phenomenon of open communication between living beings can also occur between living beings (humans) and inanimate objects (humanoid robots), such as when humanoid robots respond uniquely to each human action. As a result, men will soon forget the boundary between them as living figures composed of biological matter and humanoid robots as living figures comprising non-biological points (see Figure 2).

Based on that, it is necessary to review the definition of life and consciousness. The world's different cultures may have used the notion of life and everyday consciousness differently. The other use of the words live/in, and dead/off is not so frequent to call living things animate (living biological things) and to operate

inanimate objects). However, when the humanoid robot can respond precisely to men's actions to it, conversing, and returning touches, perhaps men won't have the heart to think of it as merely an inanimate object in operation (Figure 3). The intelligent and conscious humanoid robot figure is a new phenomenon, but the desire to create a machine that can think has existed since the rise of the development of artificial intelligence from the 50s to the early 70s [6].

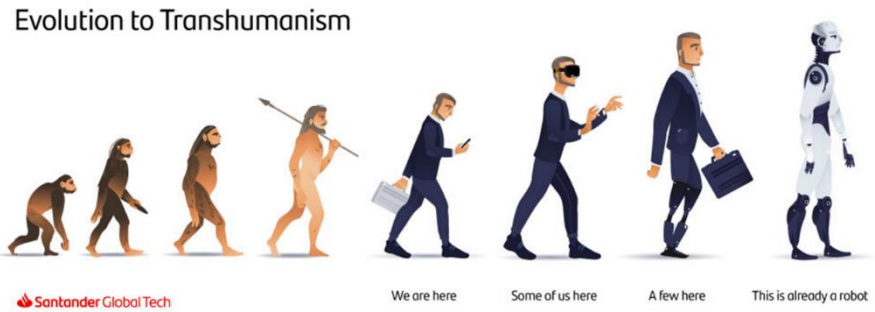


Figure 1. Evolution to transhumanism.
Source: [2]

(a) (b)

Figure 2. Interspecies communication between humans and other species
(a) interaction with a biological dog. (b) interaction with a robot dog. Source: [3],[4]

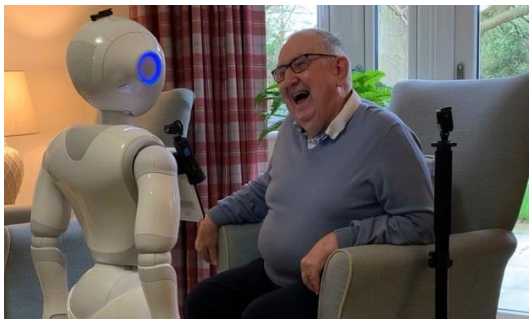


Figure 3. A humanoid robot is an inanimate working object.
Source: [5]

Architecture, specifically interior design, will become the container of human and humanoid-robot interaction, especially when the temptation to eliminate the boundaries of life/inanimate objects becomes imminent. Precedents for its presence are already rife in science fiction films. This paper explores the implications of the existence of humanoid artificial intelligence in the perspective of Architecture, from the design approach to the needs, the implications, and the compromises, especially concerning interior space design.

2. RESEARCH METHOD

This paper discusses the implications of intelligence and awareness in humanoid robots in their interactions with humans within a contained space of activities and how those interactions will affect the interior design approach in the future. This paper takes data, references, and arguments from scientific and popular sources. Acquisition Scientific sources come from published research, studies, and news about technologies and approaches tested and applied in today's everyday life. The extraction of popular resources comes from media such as films, books, and other sources regarding future technology and situations that have yet to be achieved or implemented by current technology and research. The discussion uses a descriptive and qualitative method, combining the arguments from both resources to simulate future situations in correlation with interior design. The result of the research is a synthesis of the combination, proposing a possible approach to an interior design that can cater to human and humanoid artificial intelligence that coexist within a single space.

3. RESULTS AND DISCUSSION

3.1. Humanoid Robots: artificial intelligence and artificial consciousness

Both natural and artificial intelligence and consciousness are different things that are often not easily separated. There is a specific and in-depth explanation of both of these [7][8][9][10][11]. The Oxford Dictionary defines intelligence as learning, understanding, and thinking logically. Consciousness is using your senses and mental powers to understand what is happening. Human intelligence is measured, for one, by the level of IQ (intelligence quotient). There are two types of consciousness: physical (or clinical) and mental. Clinical awareness is measured by, for one, EEG (electroencephalography). Levels of mental awareness are measured through, for one, interviews on measuring subjects by experts. Everyone has a different type of intelligence.

There is still debate today regarding the term's natural intelligence and artificial intelligence. Some experts argue that intelligence on computers is just a term to express the ability of computers to process complex data in large numbers quickly. Emotional intelligence, for example, is closely related to psychology and is claimed to be the uniqueness of the human being. However, humanoid robots can program visible emotional expressions (such as smiles) in response to a stimulus. This program is interesting because even in humans, emotions can be trained or directed (by the social environment, culture, and so on). Some machines have self-diagnostic performance checkers that monitor the entire system's performance. Immediately reporting becomes necessary if a sub-system encounters a problem. Even machines have been equipped with a way to automatically replace parts that are worn out or do not work optimally according to standards. A more complex and controlled consciousness of a machine to evaluate its function becomes considered an artificial consciousness.

Consciousness has many meanings adapted to the field that is discussing it. Clinical awareness, for example, is based on the range between coma to full consciousness. Psychologists and philosophers talk a lot about thinking awareness. Abraham Maslow, for example, offered a level of human consciousness from psychological consciousness to self-actualization. In education, specific guidelines and curricula build intelligence and awareness. One of the most widely applied educational concepts compiled by Benjamin Bloom [12] is that it includes three aspects: psychomotor, cognitive, and affection. Consciousness exists in one unity with thought. Awareness of something is the result of a thought process. However, if we only look at the expression of consciousness from visual symptoms and sounds, we need to distinguish between human and animal consciousness (non-human animals). Animals are suspected to be able to express social and aesthetic awareness. In the anthropocentric view, what the animal does is an automatic action. It is not an act done with a human-like consciousness, as animals can show the social strata between them, making strong, precise, functional, and beautiful nests. Intelligence and consciousness (in the sense of awareness) are not inseparable because they are both processed by the same tool, the brain. It is the difference in emphasis between the two that can help distinguish. The discussion in this paper simplifies the scope of both. Intelligence relates to any thought processes associated with the ability of logical and or mathematical analysis. Meanwhile, awareness is related to understanding values. That is, the meaning of both refers to the basic sense of language in general.

Future humanoid robots will have many advantages compared to humans. The phrase 'creation cannot be better than its creator' is a theological expression. God's creation cannot be better than God

himself. However, human beings have many limitations. Therefore, man makes equipment to overcome its shortcomings. For example, they are making cars to overcome human limitations in speed and power—creating airplanes to overcome human limitations in speed, energy, and space utilization. So, man deliberately makes something better than himself. A human creation only has certain advantages to overcome an existing deficiency. However, the case is different in humanoid robots. The concept of creating a humanoid robot is to imitate the human figure. Gradually, in line with the development of technology, humans are improving the quality of humanoid robots. Humans like to embody their ideas, including the concept of a humanoid robot that is better than humans in every way. The humanoid robot of the future not only achieved human-level intelligence but could be better. A robot that can do more than what humans do in general. The development of Artificial Intelligence stepped into Strong AI or Artificial General Intelligence [8], which will eventually reach the level of Artificial consciousness.

3.2. Human And Humanoid Robot Requirements: Similarity and Differences

Architecture is an expression of human intelligence and consciousness. Therefore, paying attention to complex aspects in realizing architectural work is necessary. Architects need help from experts in other fields (Figure 4). Intelligence and awareness are required so that collaboration with other areas can be helpful and produce good architectural works. This paper focuses on the primary uses of architecture that cater to humans and humanoid artificial intelligence. It reduces the complication of discussing the implications of artificial intelligence and consciousness in architecture. Architecture, in the sense of a dwelling, is one of the three basic needs of humankind. Humans generally design their buildings in order: safe, healthy, comfortable, and beautiful. In the process, humans start by designing, making, and eventually caring for the architecture. The longest time humans interact with a building, for example, a house, is when inhabiting it. Residents will 'interact' with the house inside and conduct an assessment. The most common review is in terms of convenience.

Comfort involves the senses of sight (visual), touch (thermal), smell (aroma), and hearing (acoustics, noise). Another comfort is the comfort of motion (spatial). If people feel uncomfortable, then they will adjust or adapt. The level of intelligence and consciousness comes into play in the level of sensitivity to comfort, which will be the main factor determining the need for a space for humans and humanoid artificial intelligence to function correctly. Humans have senses that become sensors of environmental stimuli. The sensor will send signals to the brain to comprehensively process and assess environmental conditions. Humanoid robots are complete with digital sensors that capture the physical condition of the environment and send alerts to a central data processor to evaluate its condition. Yet, the brain and the computer work in different ways, especially on the road to meeting the result. Only now, experts have completely parsed how the human brain works. On the contrary, computers created by humans from the simplest form to the present have very high capabilities.

However, the main difference between humans and humanoid artificial intelligence is the notion of adaptability, in which the humanoids have many advantages. An example of this difference is the different physiology of skin between them. Human skin can feel temperatures within a specific range before being exposed to frostbite or blistering. The material for making humanoid robot skin is a material that can withstand temperatures below freezing to the above boiling point. In addition, human skin is equipped with pain sensors to detect danger. Humanoid robots' skin can sense to minimize the potential for damage from impacts or incisions. However, it doesn't involve pain (although the humanoids in the sci-fi film feel pain). (Figure 5). The question would be, do humanoid robots need the comfort of the environment like humans? Such differences between the limitation of humans to reach their comfort ideal and the adaptability and the ability to change from a humanoid artificial intelligence became the grey area where the right approach to interior design is needed to cater to both advantages and disadvantages from them both.

Is it necessary to adjust the interior design if humans and humanoids interact and move together? A comfortable environment is essential to support the work process [15]. In today's interior design perspective, all considerations refer to the results of human studies. The right thing for humanoid robots is not comfort but the requirement of optimal working environment conditions. So far, the center of the four principles of comfort is humans as room users. The development of four principles (safe, healthy, comfortable, beautiful) is an understanding of humans' physical and psychological nature. Whether those principles need to be adjusted when humans and humanoids share the same space doesn't seem as simple as summarizing both needs.

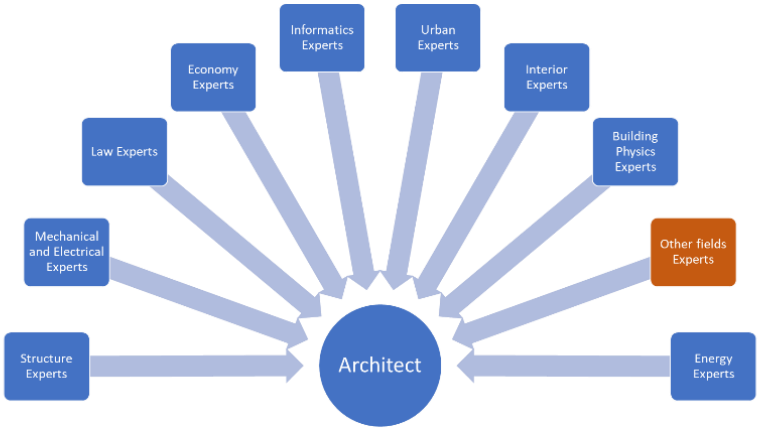


Figure 4. Architects need help from experts in other fields to do architectural works.

Figure 5. Alita, a robot with human-like intelligence and awareness, can feel pain, cry, love, and the deliciousness of food. Will robots be directed by experts in intelligence and artificial awareness? Source: [14]

Another issue of interior design for humans and humanoid artificial intelligence is the comfort of sharing a space as an equal colleague. In today's level of technology, humans still feel the existence of distance. The impression of being a soulless inanimate object on these robots is still dominant. It is easy for humans to fall in love with animals (living things) that can give a pleasant response to human actions, even though they cannot communicate verbally with each other. We still need more precedent for interaction with humanoid robots. In simple terms, humans will more readily accept a humanoid robot with a friendly visual character (fun and funny, even though it is not exactly a human face). Such acceptance will affect human and humanoid robot physical distancing. The expression of emotions on the face of a humanoid robot plays an essential role in helping communication and comfort [16][17]. However, human perception of the limitations of robot senses and the ability of robots to express themselves also affects the relationship between humans and humanoid robots. There are frequent cases of vandalism and attacks on robots, such as attacks on shipping robots. Other examples are Starship Technologies [18] and Kiwibots (which is complete with expression features) [19] (Figure 6). Human aggression towards something considered an inanimate object occurs due to the absence of sympathy and empathy for AI. Understanding AI is the fundamental basis that maintains civil interaction between humans and AI [20]. The quality of the human view of the humanoid robot will determine the preference for interior design. Thus, the anthropocentric interior design does not change. Changes will be made to those elements that are physically and characteristically necessary for optimal humanoid robots' performance.

Consciousness is a part of intelligence related to values (culture, customs, awareness of self-existence). When humans encounter humanoid robots that show consciousness, they will share their views (or reflect their opinions) on space preferences with humanoids. Such attention gives the value of familiarity, which is very important in forming a perfect cohabitation space. The increasing exposure of humanoid robots to humans requires mental readiness on the human side. The human brain will react differently between seeing humans and humanoid robots. Humans must understand social robots to be better prepared to interact with them [20]. (See Figure 7).

Figure 6. Kiwibot and the screen that shows the expression to get closer and interact with humans [21]

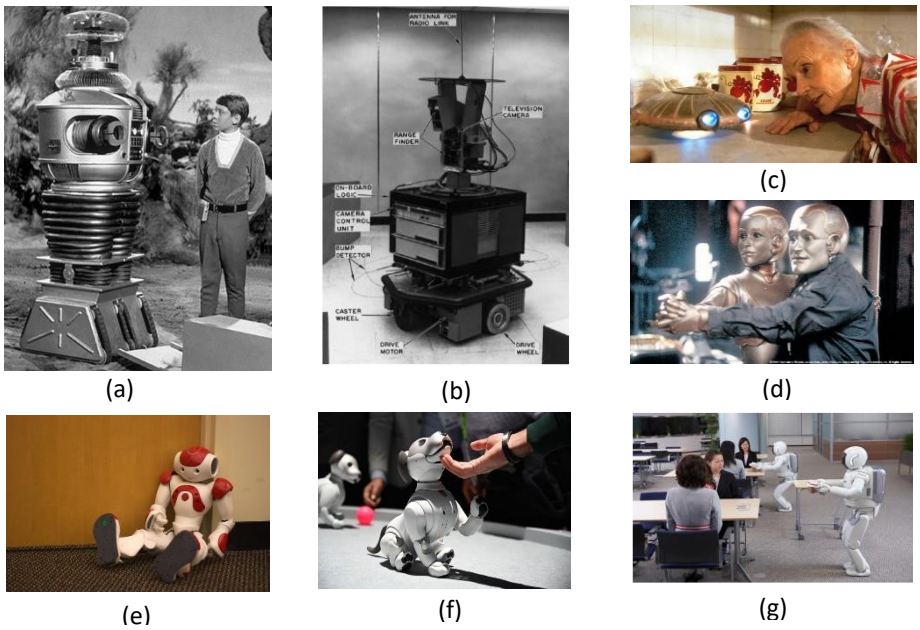


Figure 7. The conceptual and applicative interactions between men and humanoid robots (a) Robot model B-9 in "Lost in Space" Film [TV series 1965], (b) The early robot form, Shakey, was designed in the late 60s to early 70s [22]. The robot moves on wheels and is equipped with sensors to recognize the environment, (c) The film "Batteries not included" [1987] by Steven Spielberg depicts a non-humanoid robot. This an illustration that communication can bring people closer to anything, (d) the NDR series robot "Andrew" model in "Bicentennial Man" Film [1999)], (e) NAO humanoid robot developed by Aldebaran-Robotics in 2008 has a height of 0.57 m and a weight of 4.5 kg. The inspiration for NAO's look is the cartoon character Astro Boy, who is familiar to children [23], (f) A friendly non-humanoid robot that can shed human psychological limits on the difference between living and inanimate objects [24], (g) ASIMO (Advanced Step in Innovative Mobility). Honda developed the Humanoid (bipedal) robot in 1986. ASIMO's design applies the concept of "knowing and learning from humans" [25]

Human physiology and psychology are stable enough that almost the entire physiological and psychological nature of man is well known. Thus, environmental design can refer to such science. Furthermore, changes in human physiology proceed slowly through the evolutive process. On the contrary, the technology that makes up humanoid robots continues to develop rapidly so that their physical and 'psychological' properties change quickly. Thus, the creation of humanoid information corresponds to current developments and future forecasts. The table below summarizes the differences between humans and robotic humanoids that can affect the design approach of an interior design that can cater to both humans and humanoid artificial intelligence.

Table 1. Comparison between Humans and Humanoid Robots

	Normal average human (adult) (Saladin, 2014)(Palastanga and Soames, 2012)(Behnke, 2005)	**Humanoid Robots (Saeedvand *et al.*, 2019)**
Physical Body		
Height (cm)	170	Diverse
Weight (kg)	65	Diverse
Lifting force(kg)	15	Diverse
Normal road speed (m/s)	3	Diverse
Walking tools	Foot	Bipedal humanoid robots walk on foot. The foot technology in humanoid robots continues to evolve in an increasingly flexible, strong, and lightweight direction (Ding *et al.*, 2021)(Hashimoto *et al.*, 2011).
Constituents of body mass	Organic matter	Inorganic matter (cyborg type combines organic with inorganic)
Energy	Combustion of charcoal hydrate (requires oxygen)	Electricity
Energy sources	Food and drink	Electricity from renewable and non-renewable fuels is stored in batteries.
Stimulus processors	Brain	Processor
Cognitive abilities	Learn	Programmed
Cycle of work	24 hours with 8 hours of rest	24/7
Life expectancy (years)	70	It depends on the parts and software development. For example, humanoid robots that use old software and can no longer be upgraded may be turned off.
Skin	Skin tissue	It can use various materials, such as leatherette, metal, and plastic. Humanoid robot skins can be made very strong (scratch and bullet-resistant).
Water content	80%	It depends on the material used.
Sensory Range		
Vision - eyes	Visible light (380 – 740 nm), intensity 1 – 50,000 lux, purple–red spectrum.	Unlimited (can be fitted with sensors that can receive electromagnetic wave signals over a wide range.
Hearing - ear	20 – 20k dB	Unlimited (infra-sonic to ultra-sonic)
Smell - nose		Unlimited
Grope - skin	Thermals (0 – 70^{o}C)	
Taster – tongue	Sweet, salty, sour, bitter, umami (savory)	Doesn't have
Electromagnetic waves	Only in visible light	Unlimited
Comfort		
Thermal	Human thermal comfort follows a standard that combines air temperature, wind speed, air relative humidity, and average room surface radiation temperature. In addition, clothing and human activities also play a role in shaping thermal comfort. Humans secrete heat because of metabolism. In a relaxed state, the human body gives off heat by 70 W/m^2 of skin area.	Humanoid robots do not feel thermal comfort but can be given an application to 'feel' thermal comfort. Temperature and humidity have more influence on the working temperature of the equipment that drives the robot. The robot will emit heat according to its activities. Humanoid robots will probably wear efficient equipment, so they don't give off too much heat.
Audials	Human audial comfort follows audial comfort standards that are limited by sound frequency and intensity. In addition, human beings enjoy the quality of sounds or sounds (music, songs, and so on). Human vocal cords have a characteristic personal color.	The humanoid robot did not feel the comfort with the audience. However, humanoid robots can be given the ability to capture and analyze sounds. The humanoid robot's 'vocal cords' are loudspeakers that can emit various sounds, even complete orchestras.
Visual	Human visual comfort follows standards that prevent humans from glare and eye fatigue. Humans can enjoy the visual qualities of the environment based on color, light, shades, and so on. Human beings rely on the sense of sight to recognize space and move.	Humanoid robots do not feel visual comfort but can be given artificial abilities. Humanoid robots do not require human-like eyes to recognize space and move. Ultrasonic sensors can help recognize a room. However, humanoid robots can be fitted with eyes to identify the colors of the interior. The ability is in harmony with the concept of humanoids, using human characters as guidelines.
Respiratory	Human respiratory comfort follows standards that guarantee air following human respiratory needs. Humans need air, a combination of several gases (oxygen, limp substances, and so on). Humans cannot detect harmful gases such as carbon monoxide. Humans can feel the difference in aroma and enjoy it. Man draws steam from his nose.	Humanoid robots cannot feel respiratory comfort but can be given the ability to possess them. Humanoid robots do not require the composition of air like humans because they have no metabolism. Therefore, humanoid robots do not emit steam as a product of metabolism. However, humanoid robots can be fitted with scent generators.
Motion		
Axis	2D (horizontal), and 3D (through stairs).	2D and the possibility of 3D in the future as drone technology are unified with humanoid robots.
Footpath	Humans cannot repeat their movements accurately even though they can remember them.	Curved motion can be performed, and the movement of the elbow turn (perpendicular) becomes the initial character of the robot. The robot can be equipped with GPS that allows it to move precisely according to the specified coordinates. Backtraces can be recorded in detail so that they can be repeated accurately.

3.3. Interior Design: Integration of Space Between Human and Humanoid Robots

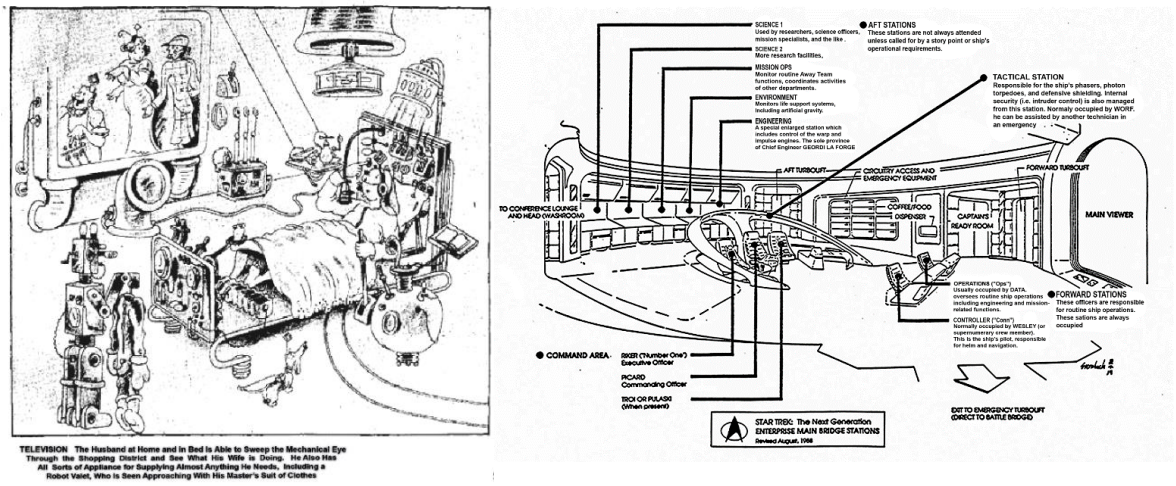
The interior is an enclosed or semi-enclosed space bounded or shrouded by planes. A combination of space configurations, barriers, environment, and furniture forms the condition and atmosphere of the interior. The layout of the space includes the main shape, magnitude, the difference in the height and low of the floor, the division of space (the organization of space), and circulation. Space limiters shape space through the type of material and its appearance. Environmental includes lighting, sound system, and air conditioning. Finally, furniture fills the space through materials, types, functions, and appearances. Table 1 shows that human nature can be imitated and applied to humanoid robots. In line with the increasingly sophisticated technology of sensors and artificial intelligence, humanoid robots can have many advantages compared to humans in the future. Yang et al. compiled ten challenges in robot science, namely: New materials and fabrication schemes, Biohybrid and bioinspired robots, New power sources, Robot swarms, Navigation and exploration in extreme environments, Fundamental aspects of artificial intelligence (AI) for robotics, Brain-computer interfaces, Social interaction, Medical robotics, and Ethics and security [32]. They are determining the development of interiors that accommodate humans and humanoid AI based on the balance point between humans and humanoid robots. To achieve this determination, through two branches, namely human adaptation to align themselves with humanoid robots or adaptation of humanoid robots to resemble humans in terms of safety, health, comfort, and beauty. The development of the interior design that overshadows the interaction between humans and humanoid robots will be more limited by humans' basic needs and limitations in using the area configuration and functions of the space. If you look at historical developments, the industrial revolution is an example of early interaction between humans and automatic mechanisms. The need for operator and maintenance limits the effectiveness of the machine room to provide an area of circulation and access for humans. The development of technology and AI will ultimately reduce the need for circulation access, along with the increasing independence of AI humanoid robots in carrying out their functions and utilities.

Technological developments, such as mechanical organ technology that replaces/improves the function of human body parts [33][34], can ultimately reduce human limitations to have the advantages of humanoid humans. Lennox conveys man's desire to become a perfect being, which is not limited to health alone, but makes a man a fitter, more beautiful, more intelligent, advanced being, less prone to illness, and does not die at a young age [35]. This equalization on the part of humans will affect the requirements and limitations of the interior design that the two types of users will use. Interior design will reduce god's need for safety, comfort, health, and beauty that orients the function of space. Meanwhile, the orientation towards the development of humanoid AI is to strive to be more humane through applying physiology and psychology, which makes humanoid AI more human-like. In this case, you cannot let go of the four aspects of the interior for granted, and the evolution of interior design development going forward will remain on the current development path.

In addition to the compatibility of needs, human and humanoid AI will also determine the interior design, where the positions between humans and humanoid AI will be aligned, or humans are in a higher stratum than humanoid AI. Asimov's three laws that attach importance to the autonomy of robots in thinking and acting still position humans on the scale of top priorities, and they are essential for humans to have as protection in the future. The more independent a robot is, it requires cognitive abilities capable of processing morality [36]. The position will determine the priority scale for the space to be given to humanoid robots. Eventually, the development of AI will reach a point where humanoid robots' judgments are comparable to those of humans. At that point, the ability level of the humanoid robot in acting and carrying out activities and the level of independence and movement will determine the intersection of space between humans and AI humanoid robots. Darling mentioned that changes in the characteristics of the relationship between humans and humanoid robots would correlate with the relationships we have established with animals so far, and this integration will go hand in hand with time [37]. Robots will eventually have the right to carry out their activities and gain sympathy and empathy from humans who will coexist with them. At this level of equality, the working relationship and workspace between humans and humanoid robots will be perfectly integrated without any hindrance (See figure 8).

Physical and digital interior spaces cannot limit the development of interactions between humans and AI humanoid robots. Brain-computer interfaces will modulate social interaction between humans and humanoid robots. Soon, humans can communicate with computers directly through brain signals. On the other hand, humanoid robots are human-shaped computers and can always communicate with humans

directly through digital signals. Therefore, it will correct the space requirements of traditional interiors. Newton D'Souza and Yu Fong Lin show spaces within virtual and physical boundaries. The continuity (continuum) between the two will determine the attachment between the place and its users [40]. So, the relationship between physical and digital must be done quickly, without any waiting time. By this time, Elon Musk had begun an effort to integrate this into humans [41] and had entered the initial experimentation stage. Still, the final application was an interior design that perfectly integrated the physical space with the addition of virtual (augmented) [42].



(a) **(b)**

Figure 8. The conceptual and applicative interactions between men and humanoid robots (a) Looking Ahead Another 50 Years by the San Antonio Light daily (San Antonio, TX), published on Dec. 04, 1932, shows an image of a humanoid robot serving as a servant showing the position of a humanoid robot below the human strata [38]. (b) The design of the bridge in the film series "Star Trek: The Next Generation" shows the integration of the same workspace between humans and Android (Data), with no separator boundary between the two types of users [39].

The interaction between humans and humanoid robots will also determine interior design's beauty (aesthetics) aspect. The ability of AI to create art has become an issue full of discussions in describing the meaning of art and the artist himself. AI's ability to process and create art through algorithms and dataset learning inputs has been developed for over 50 years, as did Harold Cohen (AARON) and Lillian Schwartz. There is debate about recognizing whether AI is an individual who creates art (artists) or just a tool for people who put input into AI [43]. It brings back the discussion of AI's position in its interactions with humans and whether there is equality (recognition). The above image shows that the integration process between humans and humanoid robots in the field of interior design will result in a disruptive interference process in the design process that exists at this time, especially in the part of human needs. Dodsworth said that one of the essential elements of interior design is the human scale so that humans will be part of the space, whatever the space's function, whatever the space's scale [44]. The impermanence of humanoid robots within the physiological and psychological boundaries possessed by humans at this time makes the human scale a non-priority scale in interior design in the future. The function and effectiveness of the representatives of the humanoid robot elements will affect the four main elements in design (safety, comfort, health, and beauty), which form the basis of human needs.

3.4. Interior Design: An Approach That Caters to Both Human and Humanoid Robots.

As for the present, the idea of a cohabitation space between humans and humanoid robots is still within the realm of simulation and conceptual space due to the technological advancements of artificial intelligence that have yet to reach the realm of artificial consciousness. Artificial Intelligence has yet to reach an equal footing with humans, making humans the priority in determining the comfort level in the interior

space. The human need would adopt artificial intelligence and its 'body,' thus maintaining the traditional interior design approach we may find today. As humanoid robots become more aware and more effective, it will require equal priority of convenience to have an ideal design approach. Thus, the level of proximity of robots to humans will determine the design approach. The statute of limitations still lies within the human's physical boundaries.

With that in consideration, there are two different pathways of an interior design approach that can happen when we consider all the discussion in previous sub-chapters, which centers on the central element of a design, the typology of the users of the space. The first approach has an interior design approach that caters to humans' need for comfort. This approach unconsciously designs a humanoid robot to resemble a human's physiological needs to function appropriately more closely. Figure 8 is an example (b), where we can see how an android, DATA, works seamlessly in a human environment and can function normally and effectively in a human environment. The interior space would be like the current design requirements and aesthetics, as humans still become the design priority of the space.

The second approach has an approach that prioritizes more functionality and compactness. This approach sees the advantages and potentials of humanoid robots that transcend a human's physiological boundaries. Humans' comfort becomes a secondary notion in design, as its limitations will hinder the space's effectiveness. This notion would foresee the pushing of humanity to adapt to become as effective as the humanoids, with implications of transcending the limitations of human comfort to have an equal footing with the humanoid robots, either by using machinations or integrating the machines into themself (see figure 9) . As a result, the interior space would become more efficient while reducing the architectural elements that are not functional. This approach will result in a more mechanized interior design in which functions triumph over aesthetics.

4. CONCLUSION

In the future, humanoid human-robot interaction will become more and more intense and become one common thing and a form of social interaction. With the application of artificial consciousness to humanoid robots (which includes artificial psychological responses), social interaction becomes more natural (from the human side). However, the physical characteristics of humans will not change radically. On the contrary, humanoid robots will continue to change according to science, technology, and art development. Interior design as a place for interaction will also change. However, the prediction of these changes is still more based on human considerations. It is because humans are slower to change or adjust than humanoid robots. The presence of a humanoid robot will give the interior color in terms of its advantages. For example, the robot does not have to sit in a chair. If the robot sits in a chair, it is only for the convenience of humans who want humanistic interaction.

Similarly, brain-computer interface technology will allow humans and humanoid robots to communicate directly through digital signals. It will correct conventional circulation and interior space standards because the need for verbal communication (conversation), which requires a certain distance for clarity, becomes less critical. Artificial consciousness, as a progression of artificial intelligence, indeed changes interior design's future in some ways. In addition, an essential element regarding the interior design approach will change along with the development of adaptation technology in humans and the development of the AI humanoid robot as another element that has the same priority scale as the human element concerning the use of interior space. Rules regarding ergonomics, comfort levels, scale, circulation, proximity, and proportions will adjust the interaction between the two users. The artistic and convenience approach will have the same priority scale as the functionality approach and the optimization of the usability of the space.

REFERENCES

[1] R. Kurzweil, "The Singularity Is Near : When Humans Transcend Biology." Penguin, 2005.
[2] "Transhumanism, Elevating the Human Condition? | Santander Global Tech." https://santandergto.com/en/transhumanism-elevating-human-condition/ (accessed Nov. 30, 2022).
[3] "Pets Are Critical For Older Adults."
[4] Jacqueline Howard, "Robot pets: Can they comfort us like the real thing? - CNN." https://edition.cnn.com/2016/10/03/health/robot-pets-loneliness/index.html (accessed Nov. 30, 2022).
[5] R. Booth, "Robots to be used in UK care homes to help reduce loneliness | Social care | The Guardian." https://www.theguardian.com/society/2020/sep/07/robots-used-uk-care-homes-help-reduce-loneliness (accessed Dec. 01, 2022).

[6] S. Natale and A. Ballatore, "Imagining the thinking machine: Technological myths and the rise of artificial intelligence," *Convergence*, 2020, doi: 10.1177/1354856517715164.
[7] D. Gamez, "The Relationships Between Intelligence and Consciousness in Natural and Artificial Systems," *J. Artif. Intell. Conscious.*, 2020, doi: 10.1142/s2705078520300017.
[8] G. W. Ng and W. C. Leung, "Strong Artificial Intelligence and Consciousness," *J. Artif. Intell. Conscious.*, vol. 07, no. 01, pp. 63–72, Mar. 2020, doi: 10.1142/S2705078520300042.
[9] P. O. A. Haikonen, "On Artificial Intelligence and Consciousness," *J. Artif. Intell. Conscious.*, vol. 07, no. 01, pp. 73–82, Mar. 2020, doi: 10.1142/S2705078520500046.
[10] J. A. Reggia, G. E. Katz, and G. P. Davis, "Artificial Conscious Intelligence," *J. Artif. Intell. Conscious.*, vol. 07, no. 01, pp. 95–107, Mar. 2020, doi: 10.1142/S270507852050006X.
[11] I. Aleksander, "The Category of Machines that Become Conscious," *J. Artif. Intell. Conscious.*, vol. 07, no. 01, pp. 3–13, Mar. 2020, doi: 10.1142/S2705078520300029.
[12] A. Churches, "Bloom's Taxonomy blooms digitally," *Tech Learn.*, vol. 196605124, pp. 1–6, 2008, [Online]. Available: http://www.techlearning.com/showArticle.php?articleID=196605124
[13] I. As, S. Pal, and P. Basu, "Artificial intelligence in architecture: Generating conceptual design via deep learning," *Int. J. Archit. Comput.*, vol. 16, no. 4, pp. 306–327, Dec. 2018, doi: 10.1177/1478077118800982/ASSET/IMAGES/LARGE/10.1177_1478077118800982-FIG2.JPEG.
[14] D. McNary, "'Alita: Battle Angel' New Trailer Debuts at Comic-Con - Variety." https://variety.com/2018/film/news/alita-battle-angel-trailer-james-cameron-robert-rodriguez-1202880975/ (accessed Dec. 01, 2022).
[15] T. J. Prescott and J. M. Robillard, "Are friends electric? The benefits and risks of human-robot relationships," *iScience*, vol. 24, no. 1, Jan. 2021, doi: 10.1016/j.isci.2020.101993.
[16] T. Kishi *et al.*, "Development of expressive robotic head for bipedal humanoid robot," in *IEEE International Conference on Intelligent Robots and Systems*, 2012. doi: 10.1109/IROS.2012.6386050.
[17] Z. Yu, G. Ma, and Q. Huang, "Modeling and design of a humanoid robotic face based on an active drive points model," *Adv. Robot.*, 2014, doi: 10.1080/01691864.2013.867290.
[18] I. Asher Hamilton, "People are kicking Starship Technologies' food delivery robots," *09.06.2018*, 2018. https://www.businessinsider.de/people-are-kicking-starship-technologies-food-delivery-robots-2018-6?r=US&IR=T (accessed Nov. 10, 2022).
[19] J. Lynn, "Why Do I Want to Kick Those Cute Little Food-Delivery Robots? | by Jessica Lynn | The Bold Italic," 2022. https://theboldítalic.com/why-do-i-want-to-kick-those-cute-little-food-delivery-robots-ba0555a144d9 (accessed Nov. 10, 2022).
[20] E. S. Cross and R. Ramsey, "Mind Meets Machine: Towards a Cognitive Science of Human–Machine Interactions," *Trends in Cognitive Sciences*. 2021. doi: 10.1016/j.tics.2020.11.009.
[21] B. Wessling, "Kiwibot brings in $7.5 million in Pre-Series A funding - The Robot Report." https://www.therobotreport.com/kiwibot-brings-in-7-5-million-in-pre-series-a-funding/ (accessed Dec. 01, 2022).
[22] A. Bhaumik, *From AI to Robotics*. 2018. doi: 10.1201/9781315372549.
[23] S. Shamsuddin *et al.*, "Humanoid robot NAO: Review of control and motion exploration," in *Proceedings - 2011 IEEE International Conference on Control System, Computing and Engineering, ICCSCE 2011*, 2011. doi: 10.1109/ICCSCE.2011.6190579.
[24] "Why are lonely Asians turning to robots for friendship? | South China Morning Post."
[25] S. Shigemi, "ASIMO and Humanoid Robot Research at Honda," in *Humanoid Robotics: A Reference*, 2019. doi: 10.1007/978-94-007-6046-2_9.
[26] K. S. Saladin, *Human anatomy*, 4th ed. New York: McGraw Hill, 2014.
[27] N. Palastanga and R. Soames, *Anatomy and Human Movement Structure and Function*, 6th ed. Elsevier, 2012.
[28] R. Behnke, *Kinetic Anatomy*. Human Kinetics, 2005.
[29] S. Saeedvand, M. Jafari, H. S. Aghdasi, and J. Baltes, "A comprehensive survey on humanoid robot development," *Knowledge Engineering Review*. 2019. doi: 10.1017/S0269888919000158.
[30] H. Ding, Z. Shi, Y. Hu, J. Li, B. Yu, and P. Zhang, "Lightweight design optimization for legs of bipedal humanoid robot," *Struct. Multidiscip. Optim.*, 2021, doi: 10.1007/s00158-021-02968-2.
[31] K. Hashimoto, Y. Yoshimura, H. Kondo, H. O. Lim, and A. Takanishi, "Realization of quick turn of biped humanoid robot by using slipping motion with both feet," in *Proceedings - IEEE International Conference on Robotics and Automation*, 2011. doi: 10.1109/ICRA.2011.5980498.
[32] G. Z. Yang *et al.*, "The grand challenges of science robotics," *Science Robotics*. 2018. doi: 10.1126/scirobotics.aar7650.
[33] H. Bennett, "Cyborgs: Inside the technology transcending biological limits | BBC Science Focus Magazine." https://www.sciencefocus.com/future-technology/cyborgs-transhumans/ (accessed Nov. 14, 2022).
[34] A. Agrawal, A. N. Dube, D. Kansara, S. Shah, and S. Sheth, "Exoskeleton: The Friend of Mankind in context of Rehabilitation and Enhancement," *Indian J. Sci. Technol.*, vol. 9, no. S1, pp. 1–8, 2016, doi: 10.17485/ijst/2016/v9is1/100889.

[35] J. C. Lennox, "2084: Artificial intelligence and the future of humanity." Zondervan, 2020.
[36] R. R. Murphy and A. Texas, "Beyond Asimov : The Three Laws of Responsible Robotics," *IEEE Intell. Syst.*, vol. 24, no. 4, pp. 14–20, 2009.
[37] K. Darling, "The New Breed." Henry Holt and Co, New York, 2021.
[38] M. Novak, "Watching Television With My Robot Butler (1932) — Paleofuture." https://paleofuture.com/blog/2011/1/28/watching-television-with-my-robot-butler-1932.html (accessed Nov. 14, 2022).
[39] "Designing the Next Generation Bridge — Forgotten Trek." https://forgottentrek.com/the-next-generation/designing-the-next-generation-bridge/ (accessed Dec. 01, 2022).
[40] J. A. A. Thompson and N. H. Blossom, Eds., *The Handbook of Interior Design*. Wiley Blackwell, 2015. doi: 10.1002/9781118532409.
[41] É. Fourneret, "The Hybridization of the Human with Brain Implants: The Neuralink Project," *Cambridge Q. Healthc. Ethics*, vol. 29, no. 4, pp. 668–672, 2020, doi: 10.1017/S0963180120000419.
[42] A. B. Craig, *Understanding Augmented Reality. Concepts and Applications*. Elsevier Inc, 2013.
[43] M. Mazzone and A. Elgammal, "Art, Creativity, and the Potential of Artificial Intelligence," *Arts*, vol. 8, no. 1, p. 26, 2019, doi: 10.3390/arts8010026.
[44] S. Dodsworth, *The Fundamentals of Interior Design*, vol. 20, no. 4. Singapore: AVA Publishing SA, 2009. doi: 10.1080/14606925.2017.1325635.

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