Springer Series on Cultural Computing

Belinda J. Dunstan
Jeffrey T. K. V. Koh
Deborah Turnbull Tillman
Scott Andrew Brown *Editors*

Cultural Robotics: Social Robots and Their Emergent Cultural Ecologies

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The future is unthinkable. Yet here we are, thinking it.
Coexisting, we are thinking future coexistence. Predicting it and more: keeping the unpredictable one open.

—Timothy Morton, Dark Ecology

Foreword

At the start of the new millennium, the rise of *social robotics*, as a novel branch of Embodied AI and HRI, has marked the beginning of a transdisciplinary undertaking bringing robotics far beyond the boundaries of engineering.

The scope of social robotics is not limited to that of a technological discipline engaged in moving, from the realm of science-fiction to that of contemporary human social contexts, machines that are able to communicate with us through social signals compatible with our own. The success reached by social robotics in building "social partners" for humans is based on innovative scientific research. To create robots that can be effectively integrated into our social contexts, social robotics embodies in these artefacts hypotheses about us, namely hypotheses generated by a wide variety of sciences (from biology to ethology, from anthropology to sociology and psychology, from cognitive sciences to semiology and epistemology…) to describe scientifically how we know, how we communicate, how we perceive each other, how we relate to our environment and our social world—in short: who we are. And, by evaluating the quality of our interactions with these machines, social robotics tests these hypotheses, both in its labs and in the field, and provide feedback on them.

Social robotics is a science. We can conceive it as an emergent form of anthropology, addressing the issue of human self-knowledge based on the research method introduced by cybernetics to study life and cognition synthetically—the "synthetic" or "understanding by building" method. Indeed, social robotics can be seen as one of the most original and comprehensive expressions of the cybernetic project of "synthetic science." A "synthetic anthropology", which, by building robotic models of humans, and introducing them into human social contexts, on one side, generates unprecedented knowledge about us, and, on the other, transforms us in unprecedented ways.

The diffusion of social robots will change us. It will transform us and our world by revealing, amplifying, and reorienting features of our sociability. It will do so in ways that we do not know or understand for now, since these changes will cause the very process by which we will know and understand ourselves and our social universe better. More than a paradox, this is a challenge, which social robotics has been imposing on us for more than two decades now: Creating a generative loop

between the process of self-knowledge and the process of self-transformation in which social robots are involving us.

Today, the birth of *cultural robotics* in the form of an autonomous research domain, as announced in this book, reflects the beginning of a new transdisciplinary adventure, in contemporary science, which promises to address this challenge proactively.

Born as a branch of social robotics dedicated to (self-)reflection on its cultural dimensions, now cultural robotics appears as an extremely original new area of study, whose specific contributions are grounded in a profound awareness of the potentialities that social robots can express in our evolution. Cultural robotics emphasizes that the project of social robots is not, nor can it be, merely technological. This new transversal domain recognizes that social robotics, while introducing its social machines as a new technology, deals also, and inseparably, with the introduction of a novel category of social relations—"human-robot" social relations. Based on this acknowledgment, cultural robotics carries a specific perception of the scale of the changes that social robots are likely to produce in our social contexts. It identifies them as complex transformations, developed through a network of circuits of co-determination (robotics-society, mind-technology, humankind-nature, natural-artificial...) which are irreducibly mediated by cultural components. For these kinds of transformations, cultural analysis can in no way be confined to specialized debates of marginal relevance. Concerning human-robot social co-evolution, cultural analysis is destined to play a concrete, decisive role, since, by directly affecting the ways we design, interpret, integrate, and live, in our public and private spaces, with the social actors produced by robotics, it exerts a deep influence both on the imminent and the long-term futures accessible to humanity in this new phase of its evolution.

One of the most promising aspects of cultural robotics' approach to the challenge of social robots is its critical inclination, which avoids the extremes polarizing current debate about these new machines—the sterile alternative between *techno-phobia* and *techno-enthusiasm.*

The complex transformations triggered by social robots—changes in our relationships with technology, with our everyday environments, with other social agents, and, ultimately, with ourselves and our identity—are perceived by cultural robotics as an opportunity.

While a negative perspective on the impacts of deploying robotic social partners tends to prevail in the scientific discourses developed by the human sciences—from philosophy to ethics, from anthropology to sociology—the research lines engaged in cross-fertilizing into cultural robotics, although centered on humans and their cultural specificities, stand for the possibility that we can make social robots means of a positive metamorphosis. Within cultural robotics, human sciences show themselves ready to engage critically and proactively in support of the ambition originally associated with the notion of social robots: building artificial agents able to play for us the role of *social connectors*, and thus facilitate, stimulate, and enhance relationships among us. In other words: making social robot tools that can help us get on the path of positive self-development, directed toward the growth of our self-knowledge, and our moral and cultural growth.

The chapters collected in this volume, in my view, converge in indicating comprehensive and virtuous ways in which we can move in this direction. Together, they represent a "creative foresight" of how we can generatively address the challenge of social robots: Creating an alliance among sciences directed to establishing an alliance with our social machines—a twofold alliance in support of our own generative (co-) evolution.

The emerging field of cultural robotics, as delineated in this volume, seems to express this view, and to implicitly promote, as a frame for our work on building synergic relationships between disciplines, between humans and machines, and among humans, what Francisco Varela, while exploring the profound biological roots of the human mind, brought forward as a "participatory epistemology" for a sustainable future: "**This world is our dance together—not my projection, nor yours; its something we do together, and what we do changes what the world is like.**"

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We extend our thanks to the international cultural robotics community, who have continued the discourse that began in 2015 and have once again entrusted their research to us in this publication.

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Chapter 1
Emergent Cultural Ecologies in Social Robotics

Jeffrey T. K. V. Koh and Belinda J. Dunstan

Abstract This chapter introduces the edited collection *Cultural Robotics: Social Robots and their Emergent Cultural Ecologies.* We present and describe the three themes that we see as contemporarily emergent within cultural robotics research: human futures, assistive technology, and creative platforms and their communities. With these themes demarcating the publication, we canvas the contributions to each section. We offer a new lens for examining the reach of social robotics, that of *cultural ecology*, where consideration for the broader political, economic, and social factors impacted by this field become inseparable to our evaluation of it. We argue for the development of social robotics to be increasingly informed by community-led transdisciplinary research, to be decentralised and democratised, shaped by teams with a diversity of backgrounds, informed by both experts and non-experts, and tested in both traditional and non-traditional platforms.

1.1 Introduction

In 2015, the authors, together with David Silvera-Tawil, held a workshop at IEEE RO-MAN in Kobe, Japan, which called for contributions attending to a relatively new premise: in what ways are social robots participants in, and creators of, culture? We were both pleased and surprised at the breadth and depth of the contributions from around the world, which signified a growing interest in the influence and contributions of robots and artificial intelligence (AI) to culture, as well as the influence of human cultures on the design and applications of social robots. As we now introduce a new collection of research on cultural robotics, we reflect on the origins and development of this field and offer an overview of what we have identified as emerging themes of research in the cultural sphere of social robotics.

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The research presented at the 2015 workshop was brought together and published as a collection of works entitled *Cultural Robotics* (2016, Springer). In the opening chapter of this book, Dunstan et. al. described how robots could not only be maintainers of and participants in human culture but could also have the potential to develop their own culture, which could quite possibly become completely unrecognisable to humans.

The authors of the contributed papers brought a variety of research; some concerning the morphology and development of social robots, while others discussed topics such as human–robot interaction (HRI) collaborative tasks, and methods for how one could evaluate HRI from sociological perspectives. More directly, chapters such as Gemeinboeck et al. discussed the socialisation of non-anthropomorphic robots via harnessing the kinaesthetic awareness of dancers; Chesher described how robots participate in the development of cinema, television, and digital media; and Marynowsky et al. shared case studies on operatic works by robotic systems. Discussions on robotic-supported food experiences were presented via Laursen et al., and Davies and Crosby wrote about the potential advent of robot-generated culture via the musical performances of the all-robot band Compressorhead. Six years later, we attempt to gauge the expanding state of the field of cultural robotics in this new collection.

With the benefit of hindsight, we have reflected on some definitions posited in the original publication, which we feel have expanded since. Although we previously defined social robotics as the foundation to cultural robotics, through our observations of these fields over the last six years, we now view these fields as engaged in a symbiotic relationship, where cultural robotics can be used as a lens to look deeper into the impact of social robotics. While our 2016 publication engaged an exciting breadth of "cultural" robotic participation, much of the content was focused on surface-level signifiers of culture, such as dance, traditional dress, music, and food. In this edition, we seek to delve deeper into what the term "culture" encompasses, across topics such as geopolitical boarders, creative community building, challenges to gender normativity, neurodiverse engagement with technology, sonic communication, personal grooming rituals, human and robotic agency, the impact and authenticity of data tracking, the historical origins and ethical implications of robot morphology typologies, and diversity-led technology design. An extensive and thoughtful discussion on all that the term "culture" encompasses can be found in the chapter presented by Bruno et al., "Culture in Social Robots for Education". The reader will also note a variety of robotic-adjacent technology included within this publication, such as biodata, NFTs, film, and sound, as we seek to understand the broadening technological ecologies that come to impact upon robotics development, and that which has a hand in shaping culture in tandem with social robotics.

1.2 Emergent Thematics

Reviewing the deeper cultural integration and impact of social robotics that has occurred since our first publication, we have summarised the emergent thematics that have provided impetus and given shape to this publication under three key streams: human futures, assistive technology, and creative platforms and their communities.

The three themes of this publication align with the key research streams of the Creative Robotics Lab (University of New South Wales, Australia) but also speak to the deeper, diverse, and generative applications for which social robots are being used.

1.2.1 Human Futures

Human futures encompass the aesthetic and ethical touchpoints between humans and social robots, including the history and future of social robot morphology design, movement planning for affective expression, sensory and sonic interaction with robots, technology ethics, material explorations of embodiment, and robotic performed sentience.

The opening chapter from Belinda J. Dunstan and Guy Hoffman traces the historical origins and cultural influences on the prevailing dominant social robot morphological typologies and issues a call to action for roboticists to engage in the aesthetic design of robots in a more informed and knowing manner. Following this, Frederic Robinson, Oliver Bown, and Mari Velonaki survey sonic robotic communication and the sonification of human actions, questioning how sound can be used to enrich human–robot interactions.

Artists Ingrid Bachmann and Vaughan Wozniak-O'Connor each discuss the use of their artworks to challenge and critique cultural assumptions. Bachmann's robots are messy, furry, "breathing" and without application, questioning the notion of creating machine life that is not necessarily productive. Wozniak-O'Connor's work renders self-tracking data as installation artworks, highlighting the disruption that technology and its shortcomings can have on traditional cultural notions such as the definition of "installation art" as well as the "white cube" of the gallery space. At the centre of the emergent robotic experience, Jeffery T. K. V. Koh discusses the notion of the AI robotic art ecosystem, where art as non-fungible tokens (NFTs) is created, traded, stored, and owned, all by robots.

1.2.2 Assistive Technologies

Assistive technologies acknowledge that technology, including robotics, has largely been designed for the "middle of the middle" and instead looks to design technology for and by marginalised populations. This research stream encapsulates those working in community-led teams, adopting a strengths-based approach to designing assistive technologies for those with disability or neurodiversity. In the realm of social robotics, assistive technologies can also include robots as household and workplace collaborators, co-workers, and assistants, as well as the design of assistive robotic objects.

Scott Andrew Brown opens this section by exploring the capacity of assistive technology to augment and empower the user. He argues for a social model of disability, where a community-led approach to technology design places the user at the centre of the design process. Melanie Tran offers insights into designing user experience (UX) and disability-focused social enterprises that redefine the concept of inclusion, and Sebastian Trew and Scott Andrew Brown offer assistive technologies as an approach for addressing the social and sensory challenges faced by autistic individuals.

Barbara Bruno and colleagues contribute a survey of the literature on social robotics for education, examining its cultural impact with focus on cultural sensitivity and adaptation. They provide guidelines for designing cross-cultural robots and systems that are culturally adaptive. Maria-Theresa Oanh Hoang and colleagues bring insights to the future use of drone swarms to assist in emergency events, with the aim of minimising distress and harm, and highlighting the opportunities of using swarms in search and rescue operations.

1.2.3 Creative Platforms and Their Communities

Creative platforms and their communities look to the creative cross-disciplinary researchers adopting robotics within their practices, those contributing creatively to more traditional robotics research, and the testing of robotics in non-traditional platforms such as museum and gallery spaces.

Deborah Turnbull Tillman brings new media and new methods of collaboration to the forefront of this section in her introductory chapter. Highlighting the disruptive and interdisciplinary nature of the technologies used in contemporary media art, she positions collaborative relationships as an effective facilitator for extending cultural experiences beyond the gallery and into the public sphere.

Within this section, authors Anca-Simona Horvath and colleagues present methods for increased accessibility and a focus on sustainability in robotics through their documented workshops for soft robotics. Their studio-based courses support transdisciplinary teaching and act as a non-traditional entry point to learning robotics. Artist Wade Marynowsky and collaborators describe sonic robotic performances that use known musical genres to position social robots as producers of culture, from an

all-robot opera to disco dancing roller skates, questioning notions of robotic agency. Performer and architect Lian Loke and Dagmar Reinhardt present work that integrates a robotic arm with intimate feminine personal-care rituals, questioning traditional boundaries of the subject and object in HRI, introducing notions of "collaborative care", and providing keen critical insight into the use of robots for cultural practices.

Concluding this section, Deborah Turnbull Tillman and Mari Velonaki explore the display of robots as cultural objects within the context of museum and galleries settings, where these settings act to both reinforce and de-silo historical taxonomies and constructs, particularly those of research disciplines. These notions are illustrated through case studies of contemporary exhibitions.

1.2.4 Platforming with Purpose

Reflecting our desire to platform non-traditional robotics research as well as essential work being conducted and communicated by neurodivergent people and people with a disability, some of the chapters within this publication may be presented in a way that is outside a traditional academic context. We wish to share the research of all our contributors in a way that allows their voices to be heard and thoughts to remain authentically structured, without being constrained by the academic tradition. We invite you to approach these chapters with curiosity; we all have much to learn from one another.

1.3 Cultural Ecologies

Social robotics has grown to include a wide range of applications, with deepening cultural implications. Beyond defining what delineates the current state of the art in cultural robotics, we wish to describe an approach to research that we envisage as beneficial to the future of robotics. Where architects can no longer afford to simply think of timber as a "sustainable material" without asking the deeper questions concerning its origin, land clearing, plantations, personnel, transport, durability, and waste disposal, social roboticists must inquire more deeply into the social, political, and cultural reaches of social robotics. Within this publication, we entitle this process *cultural ecology*.

The origins of this term stem from the term "political ecology", which has been defined by Watts (2015), and earlier by Robbins (2019), as:

> the study of the relationships between political, economic and social factors with environmental issues and changes. Political ecology differs from apolitical ecological studies by politicizing environmental issues and phenomena.

In the context of social robotics, the "environmental issues and changes" to be considered include those of the social and cultural environment. The definition of political ecology has more recently been expanded upon by Morton (2016) with broader application. In *Dark Ecology*, Morton acknowledges the complexity, nonlinearity, and interconnectedness of the socio-ecological system and calls for adaptations to be made.

> Through ecological awareness, differences between R2-D2-like beings and humans become far less pronounced; everything gains a spectral quality (p. 138).

Morton adds that,

> Coexisting with these non-humans is ecological thought, art, ethics and politics (p. 159).

In the following section, we suggest potential "adaptations" for approaching robotics research with an "ecological" awareness, to promote a more diverse and ethically engaged approach to the design and applications of social robots.

1.4 Case Studies

Technology is deeply rooted in political ecology. As current technologies develop and new technologies emerge, governments and other types of organisations seek out new ways to engage with their citizens, patrons, customers, and users. With technology, some people are included in the discourse of their society, while others become estranged for a variety of reasons–not for lack of want, but simply via a lack of access. While social robotics looks to address the user at the centre as the primary driver for the development of robotic applications, we can look to adjacent technologies that may indicate and inform future developments in the field of cultural robotics.

Rooted in maker culture, prototyping platforms such as Arduino and Raspberry Pi have allowed for a kind of democratisation across the Internet of things (IoT). This enables many new people a means to experiment with ubiquitous and pervasive technologies. Ospanova et al. (2021) discussed how IoT devices such as the Raspberry Pi have allowed students and educators a means to actively participate in prototyping, increasing engagement and positive student perception in regard to technology. This phenomenon has extended accessibility to more people to participate in the development of human–computer interaction, including social robotics. Practitioners of the fine arts, for example, are now able to develop robots and AI for cultural applications. This was the original impetus for the defining of cultural robotics (Koh et al. 2016).

Prototyping platforms and their communities, such as the one that has coalesced around the Raspberry Pi, have developed into an ecosystem based on the principles of open source and accessibility, allowing for a variety of communities a means to engage in engineering and computer science prototyping. From education to wildlife conservation, the affordances of open hardware and software have made this possible.

Regarding cultural robotics, a proprietary approach to the development and maintenance of culture would not only be self-defeating, but also impossible to govern. We feel it important to highlight that for the development of cultural robotics to flourish and be valid, an open, non-proprietary, and non-confidential approach is required. The need for these deeper issues of democratisation, access, and designing "for and with" the user is explored in Part II, "Assistive Technologies".

In this book's chapter, titled "The Future of Non-Fungible Tokens: pNFTs as a Medium for Programmatic Art Enabling a Fully Realized AI-Driven Art Ecosystem", Koh discusses the how artificial intelligence geared towards the creation of artworks can have their artworks exchanged and collected by fully autonomous artificial intelligence collectors, operating within a fully automated digital marketplace. It questions the notion of not only art making (cultural artefact development), but also the notion of what it is to buy, sell, and collect artworks in an age of artificial intelligence.

Further to non-proprietary approaches to technology, distributed ledger technologies (DLTs) such as blockchain allow for decentralised communities to form around open standards and transparency. While there has been much criticism on the environmental impacts of technologies such as Bitcoin, advances in this space have quickly moved to address some of these concerns. Incumbents such as Ethereum are quickly moving towards proof-of-stake algorithms versus energy inefficient models such as Bitcoin's proof-of-work, and others such as Cardano have fully adopted low-energy models such as proof-of-stake from the onset, utilising exponentially less energy than previous generations of DLTs. These decisions have not been driven by a centralised institution but by fully distributed and autonomous organisations. For cultural robotics to gain a significant foothold in the zeitgeist of social robotics, it must adopt decentralised approaches to the encoding of cultural norms in order to best serve the communities these robots are being made for.

As we move towards digitising culture via cultural robotics, a transformation in the economy of cultural goods will occur. Cultural robotics has much to adopt from the technologies mentioned above, not in terms of their techniques but in the way that their communities and design principles are formed, to enable a rich cultural robotics ecosystem to emerge.

1.5 Conclusion

This introduction summarises the three themes that we see as contemporarily emergent within cultural robotics research: human futures, assistive technology, and creative platforms and their communities. We offer a new lens for examining the reach of social robotics, that of a cultural ecology, with consideration for the political, economic, and social factors that impact the development of the field.

Within this introduction and the chapters supported in this publication, we argue for the development of social robotics to be increasingly informed by community-led transdisciplinary research, to be decentralised and democratised, shaped by teams with a diversity of backgrounds, informed by both experts and non-experts, and

tested in both traditional and non-traditional platforms. In this way, we posit the field of cultural robotics as an ecological approach to encompassing the widest possible spectrum of human experience in the development of social robotics.

We are honoured by the deep cultural and disciplinary diversity of the authors who have contributed their research to this publication. The curiosity and critical examination evident in their work truly offers a cultural ecology of the deeper implications of social robotics in the present day, as well as speculating on the near future. The chapters herein incidentally approach common themes within social robotics from various perspectives, often challenging or compounding the positions of the others. We welcome this robust discourse as being vital to the future development of social robots. While in no way exhaustive of the reach of robotics, this collection cements the role of social robots as independent contributors to and producers of a vast array of culture, worthy of ongoing critical examination.

List of Terms

Social Robotics
A social robot is an autonomous robot that interacts and communicates with humans or other autonomous physical agents by following social behaviours and rules attached to its role. Like other robots, a social robot is physically embodied (avatars or on-screen synthetic social characters are not embodied and thus distinct). (Henschel, A., Laban, G., Cross, E. S. [2021]. "What Makes a Robot Social? A Review of Social Robots from Science Fiction to a Home or Hospital Near You". Current Robotics Reports. Springer Nature: 9–19. https://doi.org/10.1007/s43154-020-00035-0.)

Political Ecology
Political ecology is the study of the relationships between political, economic, and social factors with environmental issues and changes. Political ecology differs from apolitical ecological studies by politicising environmental issues and phenomena (Robbins 2019).

Distributed Ledger Technology (DLT)
A distributed ledger (also called a shared ledger or distributed ledger technology or DLT) is the consensus of replicated, shared, and synchronised digital data that is geographically spread (distributed) across many sites, countries, or institutions (Distributed Ledger Technology: beyond block chain).

Blockchain
A blockchain is a type of distributed ledger technology (DLT) that consists of growing list of records, called blocks, that are securely linked together using cryptography (Narayanan, A., Bonneau, J., Felten, E., Miller, A., Goldfeder, S. [2016]. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton: Princeton University Press. ISBN 978-0-691-17169-2).

Non-Fungible Token (NFT)
A non-fungible token (NFT) is a unique digital identifier that cannot be copied, substituted, or subdivided, that is recorded in a blockchain, and that is used to certify authenticity and ownership (https://www.merriam-webster.com/dictionary/NFT).

Internet of Things
The Internet of things (IoT) describes physical objects (or groups of such objects) with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications network ("Internet of Things Global Standards Initiative". ITU. Retrieved 26 June 2015).

User Experience (UX)
User experience (UX) is the experience that products create for the people who use them in the real world. It is about how a product works on the outside, when people come into contact with it (Garrett, J. J., 2011. The elements of user experience: user-centred design for the web and beyond (voices that matter). *New riders*, *2*.

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Part I
Human Futures

Chapter 2
Social Robot Morphology: Cultural Histories of Robot Design

Belinda J. Dunstan and Guy Hoffman

Abstract Social robot morphologies are not conceived in a void but build on cultural trajectories of artifact design that precede them. We suggest three design tropes that are predominant in many robots morphological design choices: the human replica, the futuristic machine, and the cute companion. We discuss the first two of these tropes in the context of their historical origins, and the third from a contemporary lens. For all three, we present cultural implications of the aesthetic typologies to emphasize the critical importance of conscious engagement with these contexts when designing social robots.

2.1 Introduction

The physical appearance of a robot does not suddenly materialize from the imagination of its designer but exists within a cultural history of artifact design, drawing on this history and its traditions. Yet many designers of social robots do not recognize or acknowledge their design's position as part of a lineage of cultural traditions, instead citing interaction requirements, user preferences, or pure inspiration as the basis for their design choices (see: the "motivation" column in Dunstan (2019), *Twenty-Five Robots in Twenty-Five Years*).

This lack of acknowledgment can limit or complicate the reception and treatment of robots and the subsequent success in interaction with social robots. In her consideration of *Robots in Society, Society in Robots*, Šabanović (2010) identified that the design of social robots had been primarily developed in a unidirectional, technologically determinist manner, where technology is developed in a linear fashion of continual progress and society fulfills a passive role by accepting and adapting to the results of technical innovation. Due to the highly social contexts for which

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social robots are designed, Šabanović called for a move away from the technocentric forward-march of social robot development and instead proposed a "bidirectional shaping" between society and robots that

> paves the way for approaching design in a value-centred manner, consciously incorporating social and cultural meaning-making into design.

Šabanović proposed that it was not sufficient to consider the social and cultural impacts of a robot in post-production user testing, but rather that

> the meaning of various technological choices ... should be questioned throughout the process of technology design (2010, p. 445).

Šabanović also notes that the integration of robots into broader society should incorporate the study of both the social and technical aspects of the technology. While there is a significant body of contemporary critical theory concerning aesthetic trends in technological product design and the emergence and acceptance of social robots, the identification and analysis of aesthetic trends and their origins, specifically in social robot morphology, is necessary to foster a more conscious incorporation of social values and cultural meaning into these artifacts that are being designed to share social spaces with humans.

In this chapter, we aim to map several cultural trajectories of artifact design that lead up to contemporary social robot morphologies. We suggest three design tropes that are present in many robots morphological design choices. The first is that of the human replica, a wish to artificially recreate with mechanical means the naturalistic structure of a human. The second is that of the futuristic machine, a neutrally designed, streamlined device that is often represented through clean lines and neutral color palettes, suggesting a better-than-nature efficiency. The third is that of the cute toy or companion, emphasizing child-like or pet-like features and suggesting a certain naïvité, helplessness, vulnerability, and loyalty. We discuss the first two of these tropes in the context of their historical origins, and the third from a contemporary lens. For all three, we present the cultural implications of these aesthetic typologies for robots.

Social robot morphology has been surveyed several times in the existing HRI literature. However, these surveys are often in the form of categorical classifications of robot forms with limited cultural or historical analysis (Hegel et al. 2009; Diana and Thomaz 2011; Mahdi et al. 2022). We start to fill this gap by tracing some historical and cultural origins of social robot design, which reveal underlying notions about the function of technology that echo in contemporary applications and contexts.

In Sect. 2.2, we trace the origins of the human replica from antiquity through the design of clockwork automata to the "steam men" of the Victorian age. In Sect. 2.3, we discuss the transition of design from the naturally inspired to the machine-centric in the twentieth century. We particularly emphasize the evolution of the streamlined aesthetic through post-Industrial Revolution Italian Futurism, suggesting an ideology of speed, efficiency, and hygiene.

We then move to a more contemporary lens. Section 2.4 presents the development of a cute aesthetic for social robots, exemplified early on in robots such as Kismet,

Leo, and iCat, and persistent in the quarter-century since in contemporary research robots such as Blossom and commercial robots such as Pepper, Astro, and Otto. We detail the development and persistence of this typology in social robot design, along with its ethical implications, through the lens of Sianne Ngai's aesthetic theory.

To create robots for effective and affective interaction, social roboticists must design morphologies with an awareness of the cultural origins and social implications of their chosen aesthetics, just as designers in any other discipline would.

2.2 The Human Replica

We start our historical analysis with perhaps the most obvious and uninspired robot design: an attempted replica of the human form. This design trope can be traced back to prehistoric human figurines and mechanically actuated puppets in antiquity but began to take on a more decidedly robot-like form in the sixteenth century through the development of clockwork automata.

The urge to recreate a semblance of intelligent life via artificial means was never culturally neutral and has often been consciously related to questions of control, be it control over nature, over death, or over other living creatures. For example, sophisticated clockwork mechanisms were built as scientific tools to give humans control over the seasons, seas, and crops, and simultaneously inspired attempts to recreate living creatures, including humans, via mechanical means. The relationship between anthropomorphic machines and control is also evident in the robot-like designs of "steam men" in the nineteenth century, where the imagining of such steam men was closely linked to racism. We argue that the cultural associations between human form robots and control over other humans linger today, as does the notion that the design of a human-like machine, can help its designer both overcome the limitations of nature and reveal important truths about the mystery of humanness.

Humans have been creating replicas of the human form since prehistoric times, with human-like figurines dating back 35,000–40,000 years. These early sculptures indicate the long-standing interest of humans in creating artificial versions of themselves. Sculptures led to articulated and jointed masks and dolls, for example, those found in Egypt as early as the 2nd millennium BC. Some of these figures are described as being augmented with hidden voice boxes for dramatic effect. There is also written evidence of Roman wax figures that were actuated with complex mechanisms, including an attempt by Mark Antony to "revive" the dead Julius Caesar to shock a crowd of observers. Derek J. de Solla Price (1964) presents a clear and concise history of such pre-modern automata, and the reader can find an extensive presentation of ancient-to-modern automata in Chapuis (1958).

Along with the creation of these figurative representations, there is also long-documented contemplation about the possible aliveness and humanness of artificially created human figures. Two well-known examples are the Greek myth of Pygmalion from the eighth century, and the Golem, an animated anthropomorphic creature of Jewish folklore, dating back at least to the Middle Ages. In many of the treatments

of possibly-alive artificial creatures, the theme of control arises, be it over nature, death, gods, or other humans. These mythologies also usually come with moral warnings related to the hubris of control and the inevitable disaster that it brings. These questions and warnings remain to this day in the context of robotics.

The link between man-made mechanisms, artificial creatures, and control over nature clarifies during the early modern era, starting in the late fifteenth century CE and continuing throughout the sixteenth and seventeenth centuries. This period is marked by three simultaneous and interleaved developments: first, sophisticated metalwork leading to the ability to build complex spring-driven clockworks; second, the seeds of a pre-Enlightenment mechanistic and secular scientific thinking moving away from a sacred idea of humanity; and third, the expansion of European colonial empires along with a culture of exploitation.

At the same time, as European monarchies expanded their control over distant regions, including exercising control over the humans who lived in these colonies, metalwork improved to enable, among others, the construction of sophisticated measurement machines, used for long-distance ocean navigation and timekeeping. Some examples are depicted in Fig. 2.1. The increased precision of these machines—precursors of automata, then calculators, and eventually computers and robots—must have given their owners a heightened sense of control over complex natural processes. The leap from mastering the stars and seasons to mastering other living creatures and viewing them as nothing but sophisticated machines was short. De Solla Price cites St. Thomas Aquinas as stating that,

> [...] animals show regular and orderly behavior and must therefore be regarded as machines. (de Solla Price 1964)

De Solla Price adds that

> [s]urely, such a near-Cartesian concept could only become possible and convincing when the art of automaton-making had reached the point where it was felt that all orderly movement could be reproduced, in principle at least, by a sufficiently complex machine.

Fig. 2.1 Astronomical clock, circa 1568; mirror clock, ca. 1565–1570; clock-watch with sundial, ca. 1605–10