INTECH
open science | open minds

OPEN ACCESS ARTICLE

International Journal of Advanced Robotic Systems

Cultural Robotics: The Culture of Robotics and Robotics in Culture

Regular Paper

Hooman Samani[1,*], Elham Saadatian[2], Natalie Pang[3], Doros Polydorou[4], Owen Noel Newton Fernando[5], Ryohei Nakatsu[6] and Jeffrey Tzu Kwan Valino Koh[7]

1 Department of Electrical Engineering, College of Electrical Engineering and Computer Science, National Taipei University, Taiwan
2 Department of Electrical and Computer Engineering, National University of Singapore, Singapore
3 Division of Information Studies, Wee Kim Wee School of Communication and Information, College of Humanities, Arts and Social Sciences, Nanyang Technological University, Singapore
4 School of Creative Arts, University of Hertfordshire, United Kingdom
5 Centre of Social Media Innovations for Communities, Nanyang Technological University, Singapore
6 Interactive and Digital Media Institute, National University of Singapore, Singapore
7 National Institute for Experimental Arts, College of Fine Arts, University of New South Sales, Australia
* Corresponding author E-mail: hooman@mail.ntpu.edu.tw

Received 25 Feb 2013; Accepted 15 Oct 2013

DOI: 10.5772/57260

Abstract In this paper, we have investigated the concept of "Cultural Robotics" with regard to the evolution of social into cultural robots in the 21st Century. By defining the concept of culture, the potential development of a culture between humans and robots is explored. Based on the cultural values of the robotics developers, and the learning ability of current robots, cultural attributes in this regard are in the process of being formed, which would define the new concept of cultural robotics. According to the importance of the embodiment of robots in the sense of presence, the influence of robots in communication culture is anticipated. The sustainability of robotics culture based on diversity for cultural communities for various acceptance modalities is explored in order to anticipate the creation of different attributes of culture between robots and humans in the future.

Keywords Cultural Robotics, Robotic Philosophy, Evolution

1. Introduction

As technology rapidly advances, the role of the robot is changing from that of a tool to a social entity. Radical technological changes not only have affected the role and notion of robots, but have also shaped social practices. On the one hand artificial intelligence has the potential to facilitate the development of robots as emotional and intellectual entities, and in the future transform them into independent creatures instead of human agents. On the other hand we as human beings are becoming strongly attached to our technological devices in ways that could be perceived as extensions of ourselves, and are therefore embodied within us. "We are all already cyborgs" [1]. For thousands of years tools have been modifications of the self. Currently tools are becoming extensions of the self, although not just a physical extension of the self, but also an extension of the mental self.

The emergence of robotics culture, which is facilitated by the potential of cohabitation between humans and robots, not only raises issues of robot abilities but of human vulnerabilities [2], as well as the ways that robots effect our lives. These future-oriented, social entities often depict "technological fixes" [3].

In contemporary society, technological agents, including disembodied technologies and embodied robots, support our lives in a variety of dimensions. These agents live alongside humans as nurses [4], babysitters [5, 6], collaborators [7], playmates [8], leaders [9], and even intimate partners [10–12]. "Robot Culture" focuses on technologies that not only do things for humans, but also do things to and with humans [3]. Therefore, notions of robot culture not only rely on technology, but are also affected by the interpersonal, cultural, social, historical, ethical and psychological dynamics of these new socio-technical systems [13].

In this study we review the historical movement of robots from simple tools to luxury objects and then to members of human society, and eventually part of our culture. We then investigate the ways by which different cultures approach robotics. Finally, we reflect on the recursive impacts of robotics on human social practices.

2. Definition of Culture

The notion of culture has been studied in many disciplines under different titles [14]. Cultural researchers from different disciplines tend to concentrate on different features of culture. The word culture is used to describe activities and attitudes, points to the heritage or customs of a group, or expressions of similar rules and standards, or can be used to describe similar interests, cultural attires and food, housing and technologies, and many other, wide-ranging social practices [15, p.3].

Traditionally, culture has been studied within the field of Anthropology and Archaeology, with the focus on the external layers of culture such as artefacts, languages and customs [3]. With the increase in cross-cultural interactions, the description of culture has evolved to include human-to-human communication. It has been recognized that culture is a multi-layered, multi-dimensional construct. It has been commonly agreed that culture is distinguishably different from individuality states as it is a social concept. It is a group's shared set of specific basic beliefs, values, practices and artefacts that are formed and retained over a long period of time [3].

In the field of computing, culture is about supporting the user with the ability to experience an interaction that is closely attributed to the fundamental aspects of his or her culture. In a way that allows him or her to engage with an augmented reality using the values and aspects of his or her personal culture [16]. This definition is based on the concept called "Kansei Mediated Interaction", which is a form of multimedia communication that transmits non-verbal, emotional and Kansei information such as unconscious communication. It is a mixture of "Kansei Communication" (i.e., "content") and "Kansei Media" (i.e., "form") [17, 18].

In all of the above-mentioned descriptions, culture is described as a by-product of humanity. However, since many features of human life are shared with other animals, culture can be attributed to animals as well (e.g., animals are social, invent and use tools, communicate with each other) [15, p.9]. Similarly robots, due to their embodiment, intelligence, social abilities and other shared behaviours with humans, could potentially evolve culture; therefore, the evolution of robot culture in approaching futures is foreseeable. However, it is acknowledged that there is still a sizeable gap between human abilities and the current state-of-the-art robotics. The emerging discipline of cultural robotics, in our description, defines culture as a notion which is not only attributed to humans, but also encompasses the cultural exchanges between robots, robots and humans, as well as other intellectual and emotional entities.

3. Cultural Robotics

The roots of the concept of breathing life into an object of one's own creation dates back to ancient Greek legends. Daudalus used quicksilver to install a voice in his statues, Hephaestus created "automata" to help in his workshops, and Pandora was made from clay at the behest of Zeus. Pygmalion, the great Cypriot sculptor, carved a woman out of ivory and with the help of Aphrodite changed her into a real woman. Re-animated constructs have been interacting with humans and Gods throughout mythology and inevitably these ideas and concepts have been later introduced to classical literature and more recently into popular, contemporary culture.

The release of Shelley's Gothic masterpiece Frankenstein in 1818 has acted not only as inspiration to a plethora of novels that followed, but also introduced theoretical concepts that are still debated in the present day, essentially providing a prototypical framework to cyborg theory. When Victor Frankenstein bestowed animation on lifeless matter [19, 57] his creation began a long process of self-discovery. By acquiring language through listening to others and reading Milton's Paradise Lost and Plutarch he began to question his existence: "My person was hideous and my stature gigantic. What did this mean? Who was I? What was I? Where did I come? What was my destination? These questions continually recurred, but I was unable to solve them." [19, 116].

The creature in Frankenstein was able to comprehend the world around him and his place in the world. He had freedom to act according to his own free will, allowing him to make conscious decisions on his actions. A common theme that usually arises during theoretical discussions about the relationship and the interaction between humans and robots is whether robots are capable of displaying enough qualities of self-awareness that can constitute a consciousness. David Levy, in his paper "The Ethical Treatment of Artificially Conscious Robots" [20] gives an account of various definitions of consciousness, stressing how most of them are vague. De Quincey [21, 210] states "confusion about consciousness is widespread - even among professionals who study it", but goes on, describing the philosophical meaning of consciousness as "the basic, raw capacity for sentience, feeling, experience, subjectivity, self-agency, intention or knowing whatsoever" [21, 210].

Levy, quoting Aleksander Igor, goes on to say that also amongst other necessities for consciousness is prediction [22] but, as he would rather avoid concentrating on philosophical questions, Levy defines consciousness using an analogy with Alan Turing's famous test for intelligence in a machine [21, 211] which argues that "if a machine exhibits behavior of a type normally regarded as a product of human consciousness (whatever consciousness might be), then we should accept that machine has consciousness" [21, 211].

Stelarc, a renowned artist experimenting with robotic augmentations, on the other hand argues that the "body is biologically inadequate". He considers the body an impersonal, evolutionary and objective structure, and constantly explores ways to redesign it. Stelarc believes that by taking a more fundamental physiological and structural approach, the human psyche might in time develop a different outlook on how the world is perceived, thus developing new thoughts and philosophies [D5]. "Our philosophies", Stelarc continues, "are fundamentally bounded by our physiology; our peculiar kind of aesthetic orientation in the world; our peculiar five sensory modes of processing the world; and our particular kinds of technology that enhance these perceptions" [23]. As humans we are currently following a technological trend that dictates the constant development of newer technologies to drive our way of living. A few examples of these technologies include: online social networks, virtual worlds, mobile devices, medical augmentations and navigational systems. Technological gadgets are no longer acting as platforms between the interaction of two humans, but rather between humans and machines - building layer upon layer of technological mediation for our basic five senses.

Following on from this trend it would not be an exaggeration to argue that in a few years the relationship between man and machine will reach even deeper stages of fusion. The artist Orlan, famous for her frequent body transformations, believes that in "future times we'll change our bodies as easily as our hair colour" [24, p.13,14]. Stelarc argues that "(even if) most of your body is made of mechanical, silicon or chip parts and you behave in a socially acceptable way, you respond to me in a human-like fashion, to me that would make you a kind of human subject" [23]. Going a step further, if just like in cyberpunk novels our consciousness is downloaded into another body or a virtual avatar, will that mean that a person loses their humanity? By referring to Descartes theories about duality and the Cartesian split, the body can be considered nothing more than a vessel for the soul. As far as the soul or a consciousness remains intact, with a material personification that allows an acceptable embodiment able to interact in the world, cannot be considered less of a human subject.

As more humans are willing to accept robotic augmentations, we can be drawn to the conclusion that humans will become more inclined to accept a hybrid human-robot community. Furthermore, as robots become advanced enough to become autonomous, it is safe to assume that they will build communities of themselves, developing their own unique culture.

In this paper, we investigate the field of cultural robotics from two different perspectives: a society of humans coexisting with robots, as well as communities formed by next generation robots.

3.1. Human-Robot Culture

By human-robot culture, we refer to the recursive impact of cultural values of human society in the development of robots and the influence of robot cultural values on human beings.

Sabanovic [25] proposed the concept of a mutual shaping of robotics and society, which portrays a bidirectional interaction between society and technology. This concept suggests that social and cultural factors influence the design, application and evaluation of technologies, and affect social values and perceived norms. Different cultures have their own art, music, traditions, beliefs, and robots. In fact, robots are part of culture and are distinct due to special cultural values.

For instance, in the Jewish, Christian and Muslim faiths, idolatry is prohibited. Islam bans all icons from mosques, just as the Puritans banned icons from their churches. The Bible says, "God created man in his own image" (Genesis 1:27). This view is in opposition to the sentiments of Makoto Nishimura, a Japanese robotics pioneer, who states that "if one considers humans as the children of nature, artificial humans created by the hand of man are thus nature's grandchildren" [26]. With this reflection in mind, it could be posited that the Japanese are more open to humanoid robots, compared to other cultural communities, since they do not suffer from the guilt of making idols.

As another instance of cultural influence on robot design, we can point to popular media as depicted in films, novels and other media. As Bartneck [27] has shown, people's perception of robots relates to what is perpetuated by the media and entertainment industry. It is assumed that there are two types of robots: those who desire to be like humans and those who are evil and would like to destroy the world. There is little conceptual work in the popular media depicting that forthcoming robots might ultimately have their own, specific priorities and, eventually, their own value sets.

The roots of this perception date back to the ancient stories of different cultures. Whereas the passion of an assured island nation such as Japan for all types of robots, from "hundred foot tall war to infantile therapy robots" is legendary, this is in sharp contrast with the equally well-known Western anxiety of automatons, initiated with the very invention of the term "robot", which was coined in a Czech play performed in 1921 in which robots finally rise up and kill their human creators. This perception led Japanese robotic developers to design robots with the aim of changing daily life, while American robotic researchers generally concentrated on robots with military applications [28].

Although the commonsensical view is that Abrahamic culture should be against robots and Japanese culture passionate about them, due to globalization, cultural exchanges and an increase in shared cultural values, this is no longer the case. In addition, deeper behaviour analysis may lead to different perspectives. For instance, a study on attitudes towards robots among Dutch, Chinese and Japanese participants proved that the Japanese participants did not have a specifically positive attitude towards robots [29]. Another study suggests that Westerners may not think the same way as Japanese, but would change their perspective when confronted with Japanese artefacts. The contemporary behaviour towards humanoids is subtler than is commonly believed [30]. Another cross-cultural study has showed that a UK sample group was less negative towards humanoid robots compared to a Japanese sample group, although the UK sample group did not want robots to perform tasks that were associated to humans, such as empathy, caring or independent decision-making [31].

While it is acknowledged that it is not necessarily the case that the Japanese are more positive towards humanoid robots when compared to the Western community, it is still true that the cultural values of each community affect the artefacts that they create, and robots are no exception.

3.2. Robot Community Culture

"Robot Community Culture" refers to the creation of values, customs, attitudes, artefacts and other cultural dimensions among the robot community or multi-agent systems. Robot community culture is emerging as artificial culture in robot societies [32].

The notion of "Robot Culture", from this perspective, relates to the cultural construct which has emerged through purely robotic influence. Robot culture refers to values that robots themselves may hold and could eventually move towards the construction of a distinct robot culture. The prerequisites for robots to evolve "culture" in the human definition would be an independent, critical and self-reflective mind that develops in a way that leads to consciousness and, ideally, self-awareness of the robot [33]. Such a trend could lead to the creation of culture created by robots, such as robot created artefacts, robotic dance performances, robotic food, ethics and many other cultural values, and as such would be beyond the grasp of current human understanding as it would be rooted in a distinctly "robotic" condition.

Values in the context of multi-agent systems are referred to norms as part of their culture [34]. Norm modelling has been the subject of recent research on multi-agent systems [35]. In multi-agent systems, norms are categorized into rule norms, social norms, moral norms, and prudential norms that are treated as constraints on behaviour, goals to be achieved, or as obligations [36]. A variety of mechanisms are proposed for norm spreading and emergence, such as evolutionary models [37], learning from repeated local interactions in networked agent societies [38], and shared strategies in artificial agent societies [39].

Customs and attitudes would possibly evolve among robots through embodied imitation since robots are able to learn socially from one another. It is proven that repetition of a social and individual learning throughout generations brings on a cultural evolutionary process in which novelties are merged with previously developed skills, and are successfully transmitted in further generations of robots [40]. As an example, e-puck robots were used to demonstrate the emergence of artificial culture in collective robot systems. There are however limitations to cultural inheritance through imitation due to noise, the incongruousness of robots and sensor accuracy [41].

The self-replicating ability of robots could also be evidence of the possibility of artificial culture emergence among a robot society. This could be achieved by evolutionary robotic techniques, which point to the automatic creation of autonomous robots. Inspired by the Darwinian theory of selective reproduction of the fittest, robots are viewed as autonomous artificial entities that create their own skills in close interaction with the environment and without human intervention [42]. Furthermore, the ability to self-replicate and the way in which self-replication is affected by genetically encoded traits supports the creation of individuals that are shaped by several connected basic units able to coordinate and cooperate to show a coherent behaviour [43]. This coordination and coherency could support the emergence of artificial culture.

In this description we have attempted to define "robot community culture" as human-like artificial culture, programmed by humans, and human-comprehensible. However, robot-robot culture might also be alien and completely inscrutable to humans [44], which is beyond the scope of this study.

4. Embodiment

With the development of mobile and virtual forms of communications, people are mostly encountering the scenarios to perceive and act on environments that are increasingly distant and distinct from the physical world. The "Sense of Presence" enriching everyday life has attracted the attention of researchers both in the areas of remote communication and virtual environments.

The sense of presence is a multi-component and subjective concept [45] that is achieved when a person has the impression of actually being present in a remote environment. It is highly influenced by media features. Gibson-state perceptual factors help to generate this state. This includes input from some or all sensory channels, as well as more mindful intentional, perceptual, and other mental processes that assimilate incoming sensory data with current concerns and past experiences [46]. Steuer defines vividness and interactivity as determinants of tele-presence. The first vividness refers to the ability of a technology to produce a sensorially rich, mediated environment that is described as "realness" by Media artist Michael Nainiark [47], and refers to these same properties as realness. The second, interactivity, refers to the degree to which users of a medium can influence the form or content of the mediated environment [48].

To date, most researchers have worked on triggering the sense of presence and have focused on forms of mediation targeted towards the perceivable senses such as haptic stimulation and tangibility [49–53], smell and taste transition [54][55], visual cues and augmented environments [56, 57], real-timeness [58], spatial audio[59], sensory replacement to overcome personal or technological limitations, enriching the experience [60],[61], or characterizing the nature of presence and interactivity [62]. All of the above parameters trigger the sense of presence to some extent.

Although the sense of presence requires a body, it is not exclusively a mental construct. A body is clearly missing from the experience of many virtual environments (such as those rendered using HMD) and will result in an impoverished sense of presence [63].

The more embodied, holistic, joyful, mediated stimulations are available, the more illusion of actual presence is conveyed. As an evidence of behaviours related to the importance of physical matters in the perception of presence, we can mention: creating sculptures, going to temples, the instinctual tendency of children to play with dolls and toys, the understandability of classic physics in comparison to quantum mechanics [64], etc.

Users also perceive many of the features of co-presence when they share physical proximity. Proximity is important in high fidelity communication because social entities often not only rely on verbal cues, but also non-verbal signals such as body languages, posture, facial expression, eye contact and other inputs embedded in the spatial context [65]. The importance of embodied tele-presence on communication is apparent, yet relatively little attention has been paid to the human factors of joy and playfulness (affective dimension), and human physiological factors such as the role of the body and embodiment, in fostering co-presence.

Figure 1. Public train is Singapore. Almost every person is busy with a smart device.

Figure 2. Singapore, a scene before starting the dinner in a restaurant

5. Limitation of Robot Intelligence

American philosopher and professor of philosophy at the University of Berkeley, Hubert Dreyfus, has presented a compelling critique on artificial intelligence, arguing that computers will never be able to replace humans or live amongst humans as equals [66]. According to Dreyfus, robots will never be able to understand the world, as it is "organized by embodied beings like us, to be coped with by beings like us". Dreyfus goes on to say that in order for a robot to not get completely lost in the space, it needs to be able to gain experiences with each action it performs, similar to a human body. A solution would be for AI researchers to replicate and instil inside the robot a model of the world and a model of the body in order for the associations to be made, which at the current time of writing is proving to be impossible. Without this condition, the world is utterly un-graspable by computers in the same sense as their human counterparts.

Another claim against the possibility of robot culture is the limitation of creativity. Creativity involves the ability to think critically. Goldenburg in his book "Creativity in Product Innovation" [67] claims that suspending criticism and thinking that any idea is possible or good may ultimately be destructive to creativity. Humans have the ability to criticize themselves, whereas robots cannot. Even though machines can write music and poetry [68] it is eventually up to humans to decide whether the work is of any worth. Will robots be able to think creatively? As creative thinking is considered to be an essential part of generating culture, it is remains a topic for further discussion.

Robots have already shown to have a number of advantages over humans [69] making them ideal for assuming various positions within society. Even though imagining now the possibility of replacing our current cultural leaders with robots might sound absurd, by observing the current technological trends, the way technology is penetrating into our daily lives and our open acceptance to the change it affords, we could argue that giving robots positions of responsibility is not only unavoidable but is rather something desired and that we are trying to achieve.

6. Robots and the Sustainability of Culture

One of the reactions of humans to robots, known as the “Uncanny Valley”, deals with unease and even revulsion at the sight of robots that mimic humans too closely [70]. Another major concern about robots from the public perspective is the safety of robots for use in society. For example, between WWI and WWII, people were worried that robots might be built only to revolt, extinguish mankind and go on to rule the world. Horst Albert Glaser and Sabine Rossbach [71] have followed the history of robots, androids, cyborgs and clones back to ancient Greece. The acceptance of robots in human societies is therefore one of the key discourses within cultural robotics.

The study of technological acceptance has often been explored using theoretical models such as the "Diffusion of Innovations Theory" [72] and the "Technological Acceptance Model". Such studies focused on understanding factors that predict the likelihood of accepting or diffusing new innovations by individuals. However, they do not seek to address cultural influences on robots, nor do they provide further implications on how robotics might contribute to sustainable cultural practices. Both of these aspects, as we argue here, are crucial in ensuring the sustainability of robots. In other words, we suggest that the integration of robotics in cultural practices is the key to ensuring the acceptance of robots in human societies.

Using Giddens' (1984) "Structuration Theory", which argues subjectivity and objectivity of social realities as equally important, in this section we examine how robots may be imagined and theorized to contribute to the sustainability of culture. According to "Structuration Theory", cultural context is generated and regenerated through the interplay of action and structure. It recognizes that "man actively shapes the world he lives in at the same time as it shapes him" [73]. In other words, the cumulative effect of people's living and working within social frameworks is the production and reproduction of culture. Social structures both support and constrain the endeavours of individuals, communities and societies. This is also referred to as the duality of structure [73] seeing that institutional properties of social systems are created by human actions, and in turn shape future actions.

Through this formulation of structure, Giddens conceives of social structures as both constraining, enabling and involved in the production of actions. Additionally, structure is also a medium and outcome of actions. This is known as the "Duality of Structure", and integral to this concept is the function of human agency as "structure is both medium and outcome of the reproduction of practices" [74, p.5]. By this formulation of structure, Giddens also posits that structure is not fixed but is fluid and recursive, and tied to the concepts of time and space.

Giddens' concepts were further developed by Orlikowski [75] in the context of technology use. Informed by Structuration theory, she developed a recursive model (see Figure 3) of technology to demonstrate how technology both shapes and is shaped by the structure of institutions. Technology is viewed as both a product and a medium of human actions and agency, with reflexive monitoring of actions and conditions imposed on human agents in the form of institutional properties.

As illustrated, human interaction with technology (robots in our context) is always mediated by institutional conditions. In the context of cultural societies, institutional

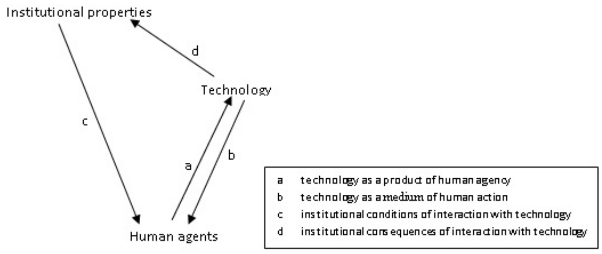

Figure 3. Orlikowski's "Recursive Model" for a "Structural Theory of Technology"

conditions are not simply organizational characteristics - they can also be cultural values, practices, interests and rituals. These conditions provide the cultural contexts by which human agents use robots (as illustrated in the arrow marked as c), but additionally, human agents project certain adaptations in using robots. In this view, human agents are not passive users and are active adapters of technology (as illustrated in the arrow marked as a). This is also supported by Suchman [76], who argues that users interact with technology using their expectations in human-to-human communication. When this happens, they shape the properties of robots using their cultural and social values. At the same time, technology is recursive: as it can present itself as a vehicle and medium for human actions (as illustrated in the arrow marked as b). The notion of technology shaping human actions is especially relevant in the case of robotics, since they can possess properties that are characteristic of interactive and intelligent artefacts [76]. In other words, any human interaction with robots is essentially a social and cultural one.

Eventually, technology is also projected as having a consequence on institutional properties (again, in our context such institutional properties refer to the cultural contexts in which human agents live and work). This is perhaps clearly seen in the cultural ramifications of robots on a typical train scene in Singapore, where people can be observed to be playing games or chatting with others on their mobile phones throughout the entire journey, even if they may be travelling with friends and family members. The use of technology changes the very cultural and social fabric of the society, thereby shaping the properties that human agents associate themselves with.

By this understanding of the recursive use of robots, we argue that robots need to be designed and used as informed by specific cultural contexts, adapted and used by human agents both as a product and a medium, and eventually manifest as cultural consequences for the society in which human agents function. Only when these conditions are satisfied can robots contribute to the sustainability of cultural practices, as well as be "sustained" by human agents, since they would have to be culturally integrated within each society.

7. Discussion and Conclusion

Looking to humankind's prehistory, it can be argued that humanity first started to develop culture when it decided to cease a nomadic lifestyle in order to settle and aggregate land. This facilitated many things including the development of communities and thus the sharing of experiences. Produce from these new regions became the hallmark of a community. Fish from communities close to water, grains from communities that grew wheat, pottery from communities that settled lands of high clay content, all these seemingly basic things are the roots of all culture. The perception of culture in human prehistory seems simple, but the impact of contemporary culture today is complex. Yet from these examples, it can be said that the conditions for fostering human culture stem from two things: a fixed location and a shared experience.

Culture, from the Latin word “cultura”, denotes the improvement of a civilization though cultivation, agriculture and horticulture[1]. In the 19th Century it came to mean the betterment of the individual through education and later on through the advent of science, was defined as the refinement of the human capacity. Currently, culture is a central concept in Anthropology that encompasses all human phenomenon.

The term "culture" in American Anthropology had two meanings: (1) the evolved human capacity to classify and represent experiences with symbols, and to act imaginatively and creatively; and (2) the distinct ways that people living in different parts of the world classified and represented their experiences, and acted creatively[2]. Culture can now be defined into two distinct groups, that of material culture (physical artefacts created by a society) and that of everything else (language, customs, etc.).

An epoch of the 21th Century, robotics has become an apex of culture both materially and otherwise. The attempt to create embodied artefacts in not just the construction of biomechanical mimicry, but ultimately of artificial intelligence and emotion [77, 78], with advances in affective computing which have brought our collected civilization into a new era where robots increasingly inherit more complex roles in our society. No longer simply a tool to service some of the more mundane tasks required by our civilization’s operational requirements, robots have become social, taking roles in medicine, therapy and even companionship.

Running in parallel to the development of computers and their roles from personal to cooperative, to social, and now cultural [16], robotics development is now reaching an increased capacity that will provide them with the faculty to be contributors and even creators of culture in the near future. Robots are contemporarily defined to exist in three categories: industrial, service and social. This manuscript proposes to extend this definition of robots into the roles of consumers, collaborators and generators of culture.

In doing so we hope to inspire further thoughts on the following questions: ’What will robotic culture look like?’ ’Will it mimic the material and immaterial culture of humanity or will it take shape in ways that are beyond our current definitions of culture?’ Even if human researchers initiate a cultural revolution within the world of robotics, robots themselves will ultimately define what robot culture will be. Yet it must also be recognized that robotics is an ensemble of both human social practices and technology, in our manuscript we have argued that because robots are both a medium and structure of human practices, it is a social construction in its own right. In other words, there may be no universal way or definition of robotics. It will be constructed diversely in different societies, and informed by the structural features of robots that have persisted over time.

Other implicit issues and future research arise out of this conception, such as the acceptance of robots in individual societies, which again must be examined closely considering the cultural contexts of the societies in which robots are being designed and implemented. Another closely associated research agenda is the effect of robotics on people, including the extent to which they impact everyday practices or contribute to both positive and negative societal transformations.

8. References

[1] Steve Mann and Hal Niedzviecki. Cyborg: digital destiny and human possibility in the age of the wearable computer. *Computing Reviews*, 46(1):6, 2005.

[2] Sherry Turkle. A nascent robotics culture: New complicities for companionship. *Online article. Retrieved January*, 6:2007, 2006.

[3] Vas Taras, Julie Rowney, and Piers Steel. Half a century of measuring culture: Review of approaches, challenges, and limitations based on the analysis of 121 instruments for quantifying culture. *Journal of International Management*, 15(4):357–373, 2009.

[4] Andres Sommer. Industrial robots for patient support. *Ion Beam Therapy*, pages 559–577, 2012.

[5] Elham Saadatian, SP Iyer, Chen Lihui, ONN Fernando, N Hideaki, AD Cheok, AP Madurapperuma, G Ponnampalam, and Z Amin. Low cost infant monitoring and communication system. In *Humanities, Science and Engineering (CHUSER), 2011 IEEE Colloquium on*, pages 503–508. IEEE, 2011.

[6] Egon L van den Broek. Robot nannies: Future or fiction? 2010.

[7] Jeffrey M Bradshaw, Virginia Dignum, Catholijn Jonker, and Maarten Sierhuis. Human-agent-robot teamwork. *Intelligent Systems, IEEE*, 27(2):8–13, 2012.

[8] Zhengtao Zhang, De Xu, and Junzhi Yu. Research and latest development of ping-pong robot player. In *Intelligent Control and Automation, 2008. WCICA 2008. 7th World Congress on*, pages 4881–4886. IEEE, 2008.

[9] Hooman Samani, Jeffrey Koh, Elham Saadatian, and Doros Polydorou. Towards robotics leadership: An analysis of leadership characteristics and the roles robots will inherit in future human society. *Intelligent Information and Database Systems*, pages 158–165, 2012.

[10] Hooman Aghaebrahimi Samani, Rahul Parsani, Lenis Tejada Rodriguez, Elham Saadatian, Kumudu Harshadeva Dissanayake, and Adrian David Cheok. Kissenger: design of a kiss transmission device. In *Proceedings of the Designing Interactive Systems Conference*, pages 48–57. ACM, 2012.

[1] http://www.etymonline.com/index.php?term=culture
[2] http://en.wikipedia.org/wiki/Culture

[11] Hooman Aghaebrahimi Samani and Elham Saadatian. A multidisciplinary artificial intelligence model of an affective robot. *Int J Adv Robotic Sy*, 9(6), 2012.

[12] Elham Saadatian, Hooman Samani, Anshul Vikram, Rahul Parsani, Lenis Tejada Rodriguez, and Ryohei Nakatsu. Personalizable embodied telepresence system for remote interpersonal communication. In *RO-MAN, 2013 IEEE*, pages 226–231. IEEE, 2013.

[13] Selma Sabanovic. Regarding robot cultures. *Japan Society*, 2005.

[14] Mark E Koltko-Rivera. The psychology of worldviews. *Review of General Psychology*, 8(1):3, 2004.

[15] David Matsumoto and Linda Juang. *Culture and psychology*. Wadsworth Publishing Company, 2012.

[16] Matthias Rauterberg. From personal to cultural computing: how to assess a cultural experience. *uDayIV–Information nutzbar machen*, pages 13–21, 2006.

[17] Ryohei Nakatsu, Matthias Rauterberg, and Ben Salem. Forms and theories of communication: from multimedia to kansei mediation. *Multimedia Systems*, 11(3):304–312, 2006.

[18] Ryohei Nakatsu, Matthias Rauterberg, and Peter Vorderer. A new framework for entertainment computing: from passive to active experience. *Entertainment Computing-ICEC 2005*, pages 1–12, 2005.

[19] Mary Shelley. *frankenstein*. Palgrave Macmillan, 2000.

[20] David Levy. The ethical treatment of artificially conscious robots. *International Journal of Social Robotics*, 1(3):209–216, 2009.

[21] Christian de Quincey. Switched-on consciousness: Clarifying what it means. *Journal of Consciousness Studies*, 13(4):7–12, 2006.

[22] José Mira and Francisco Sandoval. *From Natural to Artificial Neural Computation: International Workshop on Artificial Neural Networks, Malaga-Torremolinos, Spain, June 7-9, 1995: Proceedings*, volume 930. Springer, 1995.

[23] Paolo Atzori and Kirk Woolford. Extended-body: Interview with stelarc. *Ctheory. net*, 1995.

[24] Carey Lovelace. Orlan: Offensive acts. *Performing Arts Journal*, pages 13–25, 1995.

[25] Selma Šabanović. Robots in society, society in robots. *International Journal of Social Robotics*, 2(4):439–450, 2010.

[26] Timothy N Hornyak. *Loving the machine: The art and science of Japanese robots*. Kodansha International, 2006.

[27] Christoph Bartneck. From fiction to science–a cultural reflection of social robots. In *Proceedings of the CHI2004 Workshop on Shaping Human-Robot Interaction*, pages 1–4, 2004.

[28] Frederik L Schodt. *Inside the robot kingdom*. Kodansha, 1988.

[29] Christoph Bartneck, Tatsuya Nomura, Takayuki Kanda, Tomohiro Suzuki, and K Kennsuke. A cross-cultural study on attitudes towards robots. In *HCI International*, 2005.

[30] Frédéric Kaplan. Who is afraid of the humanoid? investigating cultural differences in the acceptance of robots. *International journal of humanoid robotics*, 1(03):465–480, 2004.

[31] Dag Sverre Syrdal, Tatsuya Nomura, Hiroto Hirai, and Kerstin Dautenhahn. Examining the frankenstein syndrome. In *Social Robotics*, pages 125–134. Springer, 2011.

[32] F.E. Griffths J.L. Bownd R. Durie J. Tennant Jackson M.D. Erbas D. Wang S. Bhamjee A. Guest A.F.T. Winfield, A.G. Sutcliffe. First steps toward artificial culture in robot societies. In *Proceedings of the 2nd European Future Technologies Conference and Exhibition*, pages 130–132. Elsevier, 2011.

[33] Dirk HR Spennemann. Of great apes and robots: Considering the future (s) of cultural heritage. *Futures*, 39(7):861–877, 2007.

[34] Bastin Tony Roy Savarimuthu, Maryam Purvis, Martin Purvis, and Stephen Cranefield. Social norm emergence in virtual agent societies. In *Declarative Agent Languages and Technologies VI*, pages 18–28. Springer, 2009.

[35] Bastin Tony Roy Savarimuthu and Stephen Cranefield. Norm creation, spreading and emergence: A survey of simulation models of norms in multi-agent systems. *Multiagent and Grid Systems*, 7(1):21–54, 2011.

[36] Raimo Tuomela. *The importance of us: A philosophical study of basic social notions*, volume 16. Stanford University Press Stanford, 1995.

[37] FACC Chalub, Francisco C Santos, Jorge M Pacheco, et al. The evolution of norms. *Journal of theoretical biology*, 241(2):233–240, 2006.

[38] Chao Yu, Minjie Zhang, Fenghui Ren, and Xudong Luo. Emergence of social norms through collective learning in networked agent societies. In *Proceedings of the 2013 international conference on Autonomous agents and multi-agent systems*, pages 475–482. International Foundation for Autonomous Agents and Multiagent Systems, 2013.

[39] Amineh Ghorbani, Huib Aldewereld, Virginia Dignum, and Pablo Noriega. Shared strategies in artificial agent societies. In *Coordination, Organizations, Institutions, and Norms in Agent Systems VIII*, pages 71–86. Springer, 2013.

[40] Alberto Acerbi and Stefano Nolfi. Social learning and cultural evolution in embodied and situated agents. In *Artificial Life, 2007. ALIFE'07. IEEE Symposium on*, pages 333–340. IEEE, 2007.

[41] Alan FT Winfield and Mehmet Dincer Erbas. On embodied memetic evolution and the emergence of behavioural traditions in robots. *Memetic Computing*, 3(4):261–270, 2011.

[42] Stefano Nolfi, Dario Floreano, and Dario Floreano. *Evolutionary robotics: The biology, intelligence, and technology of self-organizing machines*, volume 26. MIT press Cambridge, 2000.

[43] Raffaele Bianco and Stefano Nolfi. Toward open-ended evolutionary robotics: evolving elementary robotic units able to self-assemble and self-reproduce. *Connection Science*, 16(4):227–248, 2004.

[44] Susan Blackmore. Consciousness in meme machines. *Journal of Consciousness Studies*, 10(4-5):4–5, 2003.

[45] I. Alsina-Jurnet and J. Gutiérrez-Maldonado. Influence of personality and individual abilities on the sense of presence experienced in anxiety triggering virtual environments. *International Journal of Human-Computer Studies*, 2010.

[46] J.J. Gibson. The senses considered as perceptual systems. 1966.

[47] M. Naimark. Realness and interactivity. *The art of human-computer interface design*, pages 455–459, 1990.

[48] J. Steuer. Defining virtual reality: Dimensions determining telepresence. *Journal of communication*, 42(4):73–93, 1992.

[49] A.D. Cheok. Huggy pajama: A remote interactive touch and hugging system. *Art and Technology of Entertainment Computing and Communication, ISBN 978-1-84996-136-3. Springer-Verlag London Limited, 2010, p. 161*, 1:161, 2010.

[50] D. Tsetserukou and A. Neviarouskaya. World's first wearable humanoid robot that augments our emotions. In *Proceedings of the 1st Augmented Human International Conference*, page 8. ACM, 2010.

[51] R. Viciana-Abad, A.R. Lecuona, and M. Poyade. The influence of passive haptic feedback and difference interaction metaphors on presence and task performance. *Presence: Teleoperators and Virtual Environments*, 19(3):197–212, 2010.

[52] M. Slater. Special issue: Collaborative research center (sfb453) on high-fidelity telepresence and teleaction guest editor's introduction. *PRESENCE: Teleoperators and Virtual Environments*, 19(5), 2010.

[53] S.A.A. Jin. Effects of 3d virtual haptics force feedback on brand personality perception: The mediating role of physical presence in advergames. *CyberPsychology, Behavior, and Social Networking*, 13(3):307–311, 2010.

[54] N. Ranasinghe, A.D. Cheok, H. Nii, O.N.N. Fernando, and G. Ponnampalam. Digital taste for remote multisensory interactions. In *Proceedings of the 24th annual ACM symposium adjunct on User interface software and technology*, pages 79–80. ACM, 2011.

[55] G.S. Levy, P. Angel-Levy, E.J. Levy, S.A. Levy, and J.A. Levy. Telepresence by human-assisted remote controlled devices and robots, May 24 2011. US Patent 7,949,616.

[56] S.A.A. Jin. âĂIJit feels right. therefore, i feel present and enjoyâĂİ: The effects of regulatory fit and the mediating roles of social presence and self-presence in avatar-based 3d virtual environments. *Presence: Teleoperators and Virtual Environments*, 20(2):105–116, 2011.

[57] U. Bernardet, M. Inderbitzin, S. Wierenga, A. Väljamäe, A. Mura, and P. Verschure. Validating presence by relying on recollection: Human experience and performance in the mixed reality system xim. In *11th Annual International Workshop on Presence, Padova, Italy*, 2008.

[58] P. Edirisingha, M. Nie, M. Pluciennik, and R. Young. Socialisation for learning at a distance in a 3-d multi-user virtual environment. *British Journal of Educational Technology*, 40(3):458–479, 2009.

[59] P. Larsson, A. Väljamäe, D. Västfjäll, A. Tajadura-Jiménez, and M. Kleiner. Auditory-induced presence in mixed reality environments and related technology. *The Engineering of Mixed Reality Systems*, pages 143–163, 2010.

[60] S. Nanayakkara, E. Taylor, L. Wyse, and S.H. Ong. An enhanced musical experience for the deaf: Design and evaluation of a music display and a haptic chair. In *Proceedings of the 27th international conference on Human factors in computing systems*, pages 337–346. ACM, 2009.

[61] P. Seekings S. Ong L. Wyse, N. Nanayakkara and E. Taylor. Perception of vibrotactile frequencies above 1 khz by the hearing impaired. *Perception*, 0(0):0, 2010.

[62] Jeffrey Tzu Kwan Valino Koh, Roshan Lalintha Peiris, Kening Zhu, Doros Polydorou, and Ryohei Nakatsu. Uncovering analogness and digitalness in interactive media. In *Proceedings of the 30th ACM international conference on Design of communication*, pages 233–242. ACM, 2012.

[63] D. Benyon, M. Smyth, S. O'Neill, R. McCall, and F. Carroll. The place probe: exploring a sense of place in real and virtual environments. *Presence: Teleoperators and Virtual Environments*, 15(6):668–687, 2006.

[64] A. Luciani, D. Urma, S. Marličre, and J. Chevrier. Presence: the sense of believability of inaccessible worlds. *Computers & graphics*, 28(4):509–517, 2004.

[65] B.E. Mennecke, J.L. Triplett, L.M. Hassall, and Z.J. Conde. Embodied social presence theory. In *hicss*, pages 1–10. IEEE Computer Society, 1899.

[66] H.L. Dreyfus, S.E. Dreyfus, and T. Athanasiou. *Mind over machine*. Free Press, 2000.

[67] J. Goldenberg and D. Mazursky. *Creativity in product innovation*. Cambridge Univ Pr, 2002.

[68] A.D. Cheok, A.R. Mustafa, O.N.N. Fernando, A.K. Barthoff, J.P. Wijesena, and N. Tosa. Blogwall: displaying artistic and poetic messages on public displays via sms. In *Proceedings of the 9th international conference on Human computer interaction with mobile devices and services*, pages 483–486. ACM, 2007.

[69] H.A. Samani and A.D. Cheok. From human-robot relationship to robot-based leadership. In *Human System Interactions (HSI), 2011 4th International Conference on*, pages 178–181. IEEE, 2011.

[70] Chin-Chang Ho, Karl F MacDorman, and ZA Dwi Pramono. Human emotion and the uncanny valley: a glm, mds, and isomap analysis of robot video ratings. In *Proceedings of the 3rd ACM/IEEE international conference on Human robot interaction*, pages 169–176. ACM, 2008.

[71] Bern Bruxelles Frankfurt am Main, Berlin. *The Artificial Human: A Tragical History*. New York, Oxford, Wien, 2011.

[72] Everett M Rogers. *Diffusion of innovations*. Simon and Schuster, 1995.

[73] Anthony Giddens. The constitution of society. cambridge. *Polity*, 284, 1984.

[74] Anthony Giddens. New rules of sociological method (london: Hutchinson, 1977). *Studies in Social and Political Theory, London, Hutchinson*, 1977.

[75] Wanda J Orlikowski. The duality of technology: Rethinking the concept of technology in organizations. *Organization science*, 3(3):398–427, 1992.

[76] Lucy Suchman. *Human-machine reconfigurations: Plans and situated actions*. Cambridge University Press, 2006.

[77] Hooman Aghaebrahimi Samani. *Lovotics: Loving robots*. LAP LAMBERT Academic Publishing, 2012.

[78] Hooman Aghaebrahimi Samani, Adrian David Cheok, Mili John Tharakan, Jeffrey Koh, and Newton Fernando. A design process for lovotics. pages 118–125, 2011.