Friends by Design

A Design Philosophy for Personal Robotics Technology

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Abstract Small robotic appliances are beginning the process of home automation. Following the lead of the affective computing movement begun by Professor Rosalind Picard in 1995 at the MIT Media lab, roboticists have also begun pursuing affective robotics, robotics that uses simulated emotions and other human expressions and body language to help the machine better interact with its users. Here I will trace the evolution of this design philosophy and present arguments that critique and expand this design philosophy using concepts gleaned from the phenomenology of artifacts as described in the literature of the philosophy of technology.

1 Introduction

1.1 The Novel Design Issues in Personal Robotics

Robots are no longer limited to pure imagination, cyberspace, or the factory floor. Robots are finding a niche right in our homes. This requires that the machines be designed with a plastic ability to adapt to the differing lifestyles of all their potential users. The roboticist Cynthia Breazeal has coined the term *sociable robots* to describe robots with this ability.

> …a sociable robot is able to communicate and interact with us, understand and even relate to us, in a personal way. It is a robot that is socially intelligent in a human-like way. We interact with it as if it were a person, and ultimately as a friend (Breazeal, 2002, 2).

This conception of robotics directly challenges the more traditional paradigm of industrial robotics and the idea that robots are meant to do their work in isolation from human agents. In order to achieve this vision, robotics designers will need to pay more attention to human values such as the beliefs and desires peculiar to the human society that these machines are built to enter and interact with. Whereas

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workers were either replaced or had to learn to adjust to the robots that entered the factory floor, just the opposite is necessary for personal robotics to succeed.

There is, however, an alternative tradition in robotics that more readily embraces the vision of sociable robotics, which we will explore in this chapter, and that is found mostly in the consumer and service robots coming out of Asia. These robots are more playfully designed and data seems to suggest that Asian consumers are more prepared to accept these machines as a fellow agent, pet, friend, or even surrogate family member.

Certainly, this technology is not without serious ethical concerns. We need to ask the difficult questions such as: When it is correct to replace human agency with artificial agency? Will these machines serve to enhance human culture or serve to isolate us further from each other? How will we program these machines to interact with us as friends?

1.2 Robots in the Home

In 2003 a small dustpan sized robot entered the homes of many consumers (Maney, 2003). This robot, called the *Roomba*, promises to be the harbinger of a new age in personal robotics. Roboticists are now designing robots to work with people in the home and this is presenting them with many new challenges. If personal robotics is to succeed, then these machines must fit into the human lifeworld, which necessitates that an understanding of human sociality should become central to the design process of these machines.

Previous robotics technology has not been designed with much regard for seamlessly fitting into the human lifeworld. Since 1961, and the first application of industrial robotics at General Motors in New Jersey, commercial robotics technology has mainly consisted of large dehumanizing machines chiefly confined to the factory floor. Little effort was made when constructing these machines to get them to fit unobtrusively into the social fabric of those who used the machines. Robotics technology and automation has been criticized for its negative impact on the lives of factory workers; this technology made their jobs less skilled or made workers outright redundant (Garson, 1988). These machines are typically fenced off from human workers and are often very dangerous to be near while they are in operation.

The need to place a larger emphasis on designing personal robots to fit into the lives and social networks of their users is a very new problem for roboticists, since the typical design strategy in industrial robotics is to alter the lives and social networks of the user to fit the needs of the machine. In this chapter I will critique some of the most important work that has been done in social robotics. In addition to this I also want to question why we feel we need to have robotic servants. It is not clear that an automated workspace has made the lives of workers better and it is equally unclear whether automating our living space will make our home lives better. Towards the end I will also focus on the work of roboticists that resist the pedestrian notion of robots as domestic servants and see them instead as a chance for us to design new friends and companions.

2 Effective and Affective Design Paradigms in Robotics

2.1 The Growth of Robotics and Personal Freedom

The growth of the personal robotics market is showing signs of mirroring the early growth of personal computers. While this market is nowhere near as large as that of the personal computer, it is as large as that of traditional industrial robotics, and it is growing quickly. According to studies by the Japan Robotics Association, the United Nations Economic Commission, and the International Federation of Robotics, the personal and service robotics market is already equal to that of industrial robotics at about 5,400,000,000 U.S. dollars. By 2025 it is projected to be four times the size of the industrial robotics market, or about 51,700,000,000 U.S. dollars, and this is excluding military robotics and entertainment robotics which would greatly increase this dollar amount.[1]

This explosive growth is garnering the same kind of investor excitement as the dotcom boom of the 1990s and a few large trade shows have been organized to help hype the technology and funnel investment dollars into this industry.[2] Behind the hype and over exuberance occasioned by the introduction of personal robotics technology, there is an interesting and significant reality. Slowly but surely, more or less autonomous machines are making their way into our lives, from expensive robotic toys like the Sony *Aibo* robotic dog, to robotic vacuum cleaners and lawnmowers, all the way to the new crop of robotic weapons platforms currently deployed in the Middle East (Aproberts, 2004).

One of the most socially interesting developments in robotics technology has been the creation of robotic companions built to suit the emotional needs of children, the elderly, and even love sick young adults. These robots are primarily designed by Korean and Japanese companies and research centers that are keenly interested in building machines that are more than simply appliances: they are interested in making our future friends.

2.2 Design Paradigms in Personal Robotics

We can see two distinct design paradigms forming in the burgeoning personal robotics industry. For the sake of discussion I will call them the ‘effective’ and the ‘affective’ design paradigms. For example, American and European robotics companies have largely focused on very utilitarian, or effective, implementations of robotics technologies by building robotic vacuum cleaners, lawnmowers, and

[1] Data acquired here: (http://www.robonexus.com/roboticsmarket.htm).

[2] Robonexus is a consumer trade show (http://www.robonexus.com/index.html) and Robobusiness is for industry members (http://www.roboevent.com/).

weapons platforms. Japanese and Korean companies have pursued the more playful or affective aspect of robotics, building ingenious robotic pets, dolls, and humanoid companions. Sony, Honda, and Hitachi have all built extremely expensive humanoid robotic mascots that dance and wow the crowds at tradeshows and in advertising.

Effective design here refers to the interpretation of robots as tools or appliances meant to automate some formerly human activity. Effective design in robotics is the design strategy that seeks to remove some task from the human lifeworld and delegate it to robotics technology that can deal with the problem with little or no human direction. The robot effectively takes over some task that is too mundane, dirty, dangerous, or otherwise distasteful to leave to humans. An example of an effective robotic design that is already in place might be a vacuum cleaning robot that is programmed to come out of its charging station at night so it can vacuum a room and have it ready before its owners awake.

Affective design seeks to imbed the robot deeply into the lifeworld of the humans with which it interacts. These machines are built to elicit, and even 'experience' emotion, in order to bond more fully with their human users. This is an intriguing notion, and it is by far the more radical of the two design paradigms found in robotics today. It is this design strategy that we will focus on in this chapter. In sections four and five we will look at a few examples of this technology and explore some of the motivations of the engineers working on these machines.

It would be too simplistic to suggest that the differences between effective and affective robotics design are entirely accounted for by diversity in culture since we will see that there are important researchers in the West that are making many breakthroughs in the affective design paradigm and the Japanese have lead the world in building factory robots that are firmly in the effective robotics design paradigm. However, it is true that one finds a more ready acceptance amongst consumers of friendly and good-humored robotic designs in the East, especially in Japan.

Before we look at some of the interesting affective robots that have already been built, we need to review some of the insights that have influenced the robotics movement towards affective robotics design.

3 Important Factors in Affective Robotics Design

3.1 Robots and Social Psychology

The roboticist Takayuki Kanda and other researchers from the Advanced Telecommunications Research Institute Intelligent Robotics and Communications Labs in Kyoto (ATR), in conjunction with a number of Japanese Universities, have studied the psychological and sociological factors that can be observed during human robot interactions. They state that, "[f]or realizing a robot working in human society, interaction with humans is the key issue" (Kanda et al., 2001). They add that to achieve a robot that can elicit positive emotional responses from its human users, the robot needs to have some understanding of human psychology and group dynamics so that it can more fully interact with those around it.

Takayuki Kanda's ATR lab built a robot named "ROBOVIE," and studied its interactions with human test subjects. ROBOVIE has a vaguely human shape with a head, arms, torso, and a wheeled undercarriage. It is also equipped with an antenna that tracks radio frequency identification (RFID) badges worn by the humans interacting with it. This allows the robot to easily identify the different people it comes into contact with. The ATR researchers believe that a robot is only seen as intelligent by its operators if it both performs actions and expresses its ability to function in a natural and human like way (Kanda et al., 2001). For instance, just having people interact with a robotic head or some other restricted design is not going to draw out affective interactions with the machine, but a robot with a complete body that can interact with users autonomously, "…lets observers easily attribute various intentions to the robot based on its gaze-related movement" (Kanda et al., 2001). The researchers at ATR had the robot interrelate with fifty nine subjects and then asked each of them to fill out a questionnaire. The respondents rated the robot on a seven point scale between twenty eight pairs of opposite traits, such as friendly-unfriendly, exciting-dull, intelligent-unintelligent, etc. They found that close contact with an expressive robot that could accomplish various tasks brought about the most favorable impressions in the subjects (Kanda et al., 2001).

In another set of experiments, the ATR Intelligent Robotics and Communications Lab took ROBOVIE to elementary schools for extended periods of interaction with students in the classroom (Kanda et al., 2004; Kanda and Ishiguro, 2005). The robot was able to interact with students in a modest way engaging with them in about seventy behaviors, including simple games, telling them secrets, giving hugs and kisses to them, and making other friendly gestures. Takayuki Kanda and Hiroshi Ishiguro have been able to design the robot to engage in simple conversations, it can speak some three hundred sentences and understand about fifty words (Kanda and Ishiguro, 2005). This design has proven to be engaging enough to interest some children in interacting with the robot for extended periods of time. In one experiment the robot was programmed gradually to give out more "secret' information about itself depending on the amount of time the student spent with the robot and this, along with the robots ability to call out student's names, proved to be a very popular set of behaviors with the students (Kanda et al., 2004). The students wore nametags that had an RFID transmitter in them so that the robot was able to know with whom it was it was interacting. This feature allowed ROBOVIE to track the number and length of interactions it had with various students and also to attempt to deduce the friendship relationships that existed between the students in the classroom, in which it achieved to some moderate success (Kanda et al., 2004). The ATR Labs' goal is to eventually create a robot that can interact with students in a friendly manner and help teach children in the classroom while building relationships with the students and to, "…help maintain safety in the classroom such as by moderating bullying problems, stopping fights among children, and protecting them from intruders" (Kanda and Ishiguro, 2005).

Takayuki Kanda and his fellow researchers have discovered a number of interesting things about the design of affective robotics technology. Foremost is the data they have gathered that suggests that both adults and children are willing to suspend disbelief and attribute real intelligence and friendly feelings towards these machines even at the modest level of behaviors that are possible with the technology of today (Kanda and Ishiguro, 2005; Kanda et al., 2004). They have also found that the appearance of the robot is important and that reactions to the robot change when they alter its outward appearance, even when the underlying programmed behaviors remain the same (Kanda et al., 2004).

3.2 Bootstrapping Affective Human Robot Interactions Through Anthropomorphism

Research in the social psychology of human robot interactions such as what we looked at in the last section have inspired other roboticists to attempt to harness the natural psychological tendencies of humans in the design of affective robots. Since it seems that we all tend to anthropomorphize objects in our environment, this fact can make the design of affective robots much easier to accomplish. For instance, Daniel Dennett has written persuasively on “as-if” intentionality, where we often find it expedient to treat certain things we are interacting with as-if they had real intentionality (Dennett, 1996). This trend also seems to extend to the emotional realm. When dealing with affective robots, people seem willing to treat the robot as-if it really did have some fondness for them even if the engineers that built the machine would never be willing to ascribe these emotions to the machine since they know the synthetic tricks they used to simulate the emotions in the machine.

We might want to push this idea philosophically and wonder if once we have a complete understanding of neuroscience, our so called ‘real’ emotions might not turn out to be of the as-if variety Dennett describes. But let us leave that to another day. What is important to our discussion of affective robotic design is that this trick does work and should be used in designing these machines. Still, it is important not to push this psychological tendency too far. Humans are willing to ascribe abilities to machines that the machines do not have, but only to a point. Brian Duffy of the MIT Media Lab Europe reminds us that we need not attempt to build ersatz humans that will be ultimately unconvincing, but that instead we need to balance the robots, “. . . anthropomorphic qualities for bootstrapping and their inherent advantage as machines, rather than seeing this as a disadvantage, that will lead to their success” (Duffy, 2003). In other words, successful affective robots will be machines that are designed to do what machines do best, but in a way that engages the users’ natural anthropomorphizing tendencies to help embed that machine in the user’s lifeworld. This means that affective robots are best when they elicit our natural human predispositions to grant personalities to the objects around us making it easier for us to interact with the technology.

The roboticist Mashahiro Mori describes an interesting psychological barrier that roboticist must contend with, which he calls the “uncanny valley” (Mori, 1970). The uncanny valley is found by graphing the level of human likeness with familiarity, as a machine becomes more similar to humans in likeness and function it will evoke more positive feelings of familiarity. But Mori claims that after a certain point the machine will be more like a human in likeness and function but this likeness will be seen as uncanny and not desirable until the machine reaches a very high level of human likeness where he posits that the feelings of familiarity will rise again amongst the humans interacting with the machine, the uncanny valley is the area of unfamiliarity between the first and second peak of positive feelings of familiarity (Mori, 1970). Mori suggests that it is best for roboticist to design robots in such a way that they sit firmly on the first peak before the uncanny valley; they should be human like in some ways but clearly machines in others. This way they are not threatening and people will happily interact with them. This is a sound design principle if we are to build machines that enhance the human lifeworld rather than disrupt it. In the following sections we will look at some examples of how roboticists in Japan, Europe, and the United States, are thinking about ways to design affective robotics that take into account the ideas and concepts we have discussed above.

4 Affective Robotic Design in Japan

4.1 To Become a Real Atom Boy

Ever since the post war period in Japan, the humanoid robot has been a staple of toy design and the television and movie entertainment industry. Characters such as the friendly, loyal, and heroic little robot boy Tesuwan Atom, (or Astro Boy as he is marketed to the West), who was introduced to the world in a popular anime series begun in 1963, have helped to put a pleasant and obliging face on robotics technology. This interpretation of the robot is quite a bit different from the slave-master paradigm of robots typical of Western science fiction, which from the first mention of robots in the Play R.U.R. to the latest block buster movies have seen robots as menial labors that will eventually rise up to punish their tyrannical human masters. Of course this darker concept of robotics can be found in some Asian science fiction stories and the friendly robot is not absent from the West but overall there is a noticeable trend to be found here.

This friendly take on robotics technology might be based on the vastly different relationship towards technology that distinguishes Japanese culture from that of the West. One theory is that since traditional Japanese culture believes that every thing has a spiritual essence, including nonliving items, so they are more likely to be unbothered by positing some sort of real lifelikeness to machines, a prospect that we in the West find philosophically uncomfortable (Kaheyama, 2004; Perkowitz, 2004). The West, deeply influenced by the materialism/dualism debate, has more trouble with the concept of having an emotional relationship with a machine. The metaphysics of Buddhism also allows for an entirely different relationship to robots then that of the Abrahamic religions of the West and Middle East. Whereas orthodox Christians, Muslims, and Jews might see building a robot as some sort of perverse sub-creation or ultimate graven image, Buddhism allows the machine to share in the buddha-nature of its creator, or so argues the roboticist and Buddhist scholar Masahiro Mori in his book, *The Buddha in the Robot: A Robot Engineer's Thoughts on Science and Religion*:

> …if men are appearances created by the Void, then whatever men create must also be created by the Void. It must also partake of the buddha-nature, as do the rocks and trees around us. Specifically, since I myself was created by the Buddha, the machines and robots that I design must also be created by the Buddha (Mori, 1981, 179).

Mori goes on to argue that it is indeed possible to recognize the buddha-nature in a robot and to have some sort of spiritual connection to the machine, one manifestation of the buddha-nature to the other. It is very likely that these cultural values are explicitly or tacitly affecting the design of personal robotics by the Japanese and others in the East. As the philosopher Andrew Feenberg has shown, different societies and communities will produce different, alternative expressions of the dominant technological paradigm (Feenberg, 1995). We should therefore expect to see very different relationships to robotic technology between various cultures. As an article from the Japan Economic Newswire reports:

> "For the Japanese, the distinction between 'me and others' and 'man and robots' has been vague," said Norihiro Hagita, head of the Intelligence Robotics and Communication Laboratories of Kyoto who is studying the coexistence between man and robots. "This flexible sensitivity has helped produce a culture to share various jobs and experiences with robots" (Japan Economic Newswire, January 2005).

Karl MacDorman, a researcher at the robotics lab in Osaka suggests an alternative hypothesis as to why the Japanese in particular are working so hard to create personal and service robots (MacDorman, 2005). He suggests that since Japanese culture has so many social mores regarding proper interpersonal relations that can be very taxing and difficult to maintain, it is preferable to them to interact with a machine than with a fellow human being, it is impossible to embarrass a robot with a misspoken phrase or improper gesture so it is a less stressful interaction.

Both of these hypotheses are reasonable and it is possible that they are both true since a traditional cultural predisposition towards animism would reinforce the behaviours MacDorman observes. If relationships with other humans are difficult culturally, and one is predisposed to affable feelings towards robots, then it is natural that we will see the friendly behaviors towards robots that MacDorman and others find in Japanese test subjects.

4.2 Someone to Watch Over Me

More people are living longer and this is beginning to put a stress on caregivers. This stress is particularly evident in Japan where the population of the older generation outnumbers the younger generations. As a world leader in robotics technology, the Japanese have begun to deploy robots to address the problem (Biever, 2004). The hope is that one day robotic devices will provide help, monitoring, and companionship to those elderly that cannot get these things from their family or other sources.

A number of robots have already been built that attempt to serve several of the needs of this population and a few have even achieved some success. It is informative to review some of the successful robot designs to date.

Paro is a robot baby seal. It has soft white fur and big eyes with a cute little nose, and looks like an unremarkable stuffed animal (Hornyak, 2002). But under the white hygienic fur is a complex array of sensors and actuators that cause *Paro* to react in interesting and stimulating ways when someone speaks to it or pets its fur. *Paro* even behaves according to a circadian rhythm mimicking a natural sleep wake cycle. *Paro* is used for robot therapy, where the robot is brought into nursing homes and groups of the elderly are given the opportunity to interact with it. Typically they cuddle and hold it like a real animal and talk to it like it was a small infant to which the robot responds with gentle movements and sounds. Oddly enough, most of the participants find interacting with the machine compelling, and some of the patients with age related dementia even have a hard time realizing that *Paro* is just a machine (Japan Economic Newswire, 2005). Faced with the monotony of institutional life, watching television, or interacting with a robot, many of the elderly find the latter choice the most compelling.

Another problem facing the Japanese elderly is that there has been a downturn in the number of children in the country and this fact, along with the death of the extended family, means that many elderly do not interact with children as much as they might like. To address this need, the toy company Tomy, in conjunction with a bedding manufacturer, has created *Yumel* a small robotic doll. "The Yumel doll, which looks like a baby boy and has a vocabulary of 1,200 phrases, is billed as a "healing partner" for the elderly …" (Agence France Presse, 2005).[3] This doll is not much of a robot since it only moves its eyes and plays pre-recorded phrases without moving its mouth. Even so it has proven popular, which is an interesting phenomenon in itself. One may set *Yumel* to match the users sleep patterns and the users are supposed to take it to bed with them where they can cuddle with it and it will sing them sweet lullabies. In the morning it wakes its owner up at a preset time. An additional 'feature' is that it will occasionally beg you to buy it presents and new clothing, which can be obtained, of course, from Tomy. Just what the 'healing powers' of this kind of machine are is hard to tell, but nevertheless it is a popular item.

A similar toy aimed at both adults and the elderly, with children seen only a secondary market, is the doll *Primopuel*. This doll looks like Pinocchio without the nose and, like *Yumel*, also has a modest vocabulary and can babble on like a small child. This doll has proven to be very popular and Bandi, its maker, has made millions of Yen from this fad. Owners have reportedly taken to the robot as if it were a real child and it serves as a kind of surrogate for childless couples and other lonely adults (ibid). This growing market for companion robots has not, as yet, spread too far out from Japan but efforts to sell these products are proceeding in Europe and America.

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[3] The Yumel product website can be found here (http://www.tomy.co.jp/yumel/index2.asp).

5 Affective Robotic Design in America and Europe

5.1 Sociable Robots at MIT

There is also a desire to build robotic companions on the other side of the Pacific. Some of the most interesting work on this subject has come out of the *Robotic Life group* headed by Cynthia Breazeal in the MIT Media Lab.[4] Breazeal was a student of the revolutionary roboticist Rodney Brooks, and she has taken the maverick milieu Brooks brought to the AI lab at MIT and run with it in fascinating new directions. The robots created by this lab so far have garnered a great deal of media attention due to their compelling sociable qualities.

Most famous of these robots is perhaps *Kismet* a machine built to interact with people that Breazeal worked on for her doctoral dissertation at the MIT AI lab.[5] This was the first serious attempt in American academic robotics to build a machine that could interact with humans on a friendly and personal level. Her team gave Kismet some of the affective responses as they believe adding these capabilities to be "…a critical step towards the design of socially intelligent synthetic creatures, which we may ultimately be able to interact with as friends instead of as appliances" (Breazeal, 1999, 25).

Taking the lessons learned from *Kismet* the lab is now working with Hollywood special effects wizards from Stan Winston Studios to create *Leonardo* the next level in sociable robots. Where *Kismet* clearly looked like a robot *Leonardo* does a better job of hiding the fact and looks like a strange yet cute mammalian creature straight out of a movie. *Leonardo* is controlled by animatronics, but what separates it from mere expensive puppets is that its movements are completely controlled by a computer and it is programmed to react and interact with humans as humans. Leonardo looks at you when you talk to it, tries to infer your intention by your body movements and gestures, and in return gives you as the user cues on its mood and beliefs through facial expressions and body gestures.

The goal is to make machines that do not require that the user change his or her ways of being in the world and interacting with human and nonhuman agents. Breazeal feels that we have evolved a complex social system that works admirably and roboticists need to learn how to make their machines fit in with our already preexisting ways of interacting rather then foist on us an interface that is alien and hard to use (Breazeal, 2002). This is particularly necessary when dealing with non-technical users, such as users in a home where the machine needs to fit in as a fellow member of the household and not disrupt the lifeworld and practices of its human inhabitants. This constraint means that the robots must match our

[4] http://robotic.media.mit.edu/

[5] For details on Kismet: (http://www.ai.mit.edu/projects/humanoid-robotics-group/kismet/kismet.html).

physiology and be able to understand our emotions wants and needs (Breazeal et al., 2004). If that was achieved the robot might indeed appear to be the perfect companion.

5.2 Design Methodologies for Affective Robots at MIT and Media Lab Europe

Brian Duffy from Media Lab Europe has written out a list of design methodologies that he suggests would employ anthropomorphism in successful social robotic design (Duffy, 2003).

- Use social communication conventions in function and form. For example, a robot with a face that has expressions is easier to communicate with than a faceless box.
- Avoid the "Uncanny Valley." Robotics researcher Masahiro Mori argues that if a machine looks too human but lacks important social cues and behaviors it is actually a worse design then a robot with more iconic features who has the same behavior, since users will find the synthetic human uncanny or creepy unless or until it has the capabilities of a fictional robot like Data on Star Trek the Next Generation, who, even so, can be a little weird.
- Use natural motion. The motion needs to be somewhat erratic like a natural being and not perfect, flowing, and alien as is sometimes seen in digital animation.
- Balance form and function. The designer needs to not set up false expectations in the user by making the robot look better than it performs.
- Man vs. Machine. Designers need not feel constrained by making the robot fit the human form. Certainly our social infrastructure makes it important that social robots be about the same size as humans so they can fit through doors, etc., but we need not try to make synthetic humans, robots should be built to augment our abilities not simply to replace us.
- Facilitate the development of a robot's own identity. The machine needs to participate in human social interaction not just be an object within that social space.
- Emotions. The machine needs artificial emotions to make it more easily understood by non-technical users and to facilitate affective interactions.
- Autonomy. The machine needs to have its own independence and an ability to understand its role in a social context and how to navigate through that milieu (an ability I am sure we all wish we had more of).

Duffy's list is a great start and nicely condenses a number of the concerns brought up earlier in this chapter. To this list I would like to add some of the design issues mentioned by Cynthia Breazeal in her book, *Designing Social Robots, 2002*, that are not covered by the list above.

- The robot needs to have homeostatic sense of “well-being” that it can regulate through interactions with its users. It has to know what it wants, and know how to get it.
- The robot needs an appropriate attention system. It has to be able to attend to what is important and ignore what is not given the milieu it is operating in.
- The robot has to be able to give clues about its internal “emotional” state, and it also has to be able to read those off of its human users accurately.
- Learning is important and users have to be confident that the machine will learn from its mistakes.
- Eventually the machines will need, robust personalities, better abilities at discourse, a sense of empathy for their users and other robots, as well as a theory of mind, and an autobiographic memory, but these are very ambitious requirements and may take many decades to achieve.

Taken together these ideas form a concise description of the design philosophy that is being pursued by the most successful practitioners of affective robotics in the United States and Europe. In the concluding section I will offer a critique of what we have learned and offer some ideas meant to enhance the usefulness of affective robotics.

6 Concluding Remarks

6.1 Robots and Phenomenology

Robots are situated at the end of a trajectory of human technology begun with simple human directed hand tools which have evolved over history to the self directed automata that are beginning to emerge today. Robots, as artifacts, are produced out of human desires interacting with technical systems and practices, and as such they shape and are shaped by the human lifeworld that produced them. Robots are objects, but as Carl Mitcham suggests, “[t]echnological objects, however, are not just objects, energy transforming tools and machines, artifacts, with distinctive internal structures, or things made by human beings; they are also objects that influence human experience” (Mitcham, 1994, 176). Robots and humans form a cybernetic system that begins to see humans not specifically directing the behavior of the robotic agents. As machines become more autonomous they become what Mitcham calls, “containers for processes,” meaning that these technologies are not just tools but also encode their own use within their programming, taken together these machines and the technical and human systems they interact with can be described as “objectified processes” (Mitcham, 1994, 168). This means that we have to take seriously precisely what processes we are automating and how we are doing it since robots will have a certain *artifactology*, meaning that, “…artifacts have consequences; there is considerable disagreement about the character of those consequences and whether they are to be promoted or restrained”

(Mitcham, 1994, 182). I will now argue just what kinds of affective robotics systems should be promoted or restrained.

There are a number of possible critiques of personal robotic technology from the perspective of the philosophy of technology and I would like to address what I believe to be the most interesting. When we look at the strategy of building personal robotics systems that work to seamlessly automate the modern household, we can see that the objectified processes are those of the home life. The dream is to remove the workload of running a home from its inhabitants by having that work done by systems that do them for us as unobtrusively as possible, robots that do our laundry, clean, cook etc. Mitcham, inspired by the work of Ivan Illich, argues that instead of tools that do the work for us automatically, perhaps we need more tools that interact with us using our energy and guidance since:

> [t]he later less and less allow end-users to introduce their personal intentions into the world, to leave traces of themselves in those rich constructs of traditional artifice that have served for millennia as the dwelling place of humanity. Users now become consumers and leave traces of themselves only in their wastes (Mitcham, 1994, 184).

The phenomenology of humans in relation to robots is a fascinating development in the history of technology. This is a complex subject but an approach might be built on the lines of Albert Borgmann's device paradigm (1984). The device paradigm is a subtle concept but briefly put, it occurs when technology turns aspects of our lives into interactions with various black boxes and we can no longer engage with, or even understand, the underlying relationships to the world or each other that the technology or 'device' occludes. Home automation and robotics might just accelerate the process of hiding the process of home life behind a friendly façade of technology resulting in the final full commodification of our interpersonal lives. Every aspect of our home life will be fully encompassed by technology that we cannot completely understand and therefore we would be unable fully to comprehend just what it is about our home life, and our relationships with those we share our domicile with, that have been unfavorably altered by home robotics and automation. The technology will fulfill our perceived needs and we may come to see our family, and ultimately ourselves, as mere dysfunctional devices that serve no real purpose and we might work to replace them with our perfect robotic companions. This sort of critique has already made for entertaining science fiction books and movies but I think the reality might be more subtle. In the objectification of domestic procedures we may lose the ability to live artfully and replace that with simply the ability to live efficiently. Our lives will be effective but un affective.

I would like to make some modest additions to the design philosophies described in the sections above with the hope of contributing ideas that will cause us to build personal robotics technologies that will create a system of domestic relations between all the agents, human and artificial, that will come to inhabit the homes of our near future.

First, affective robots should not play lightly with human emotions. It is certain that these machines will be able to elicit real human emotions via their simulated ones, and some of these may at times be inappropriate or dangerous. To this end we should also recognize an 'uncanny valley' in the degree of emotion simulation programmed into our machine. Emotions should thus remain iconic or cartoonish so that they are easily distinguished as synthetic even by unsophisticated users.

Secondly, affective robots must be used to enhance the social world of their users and not to isolate them further. Affective robots should not be used as wholesale replacements for human interaction. As this technology becomes more compelling, the possibility of this happening is more likely. Computer and information technology has a seductively immersive quality that can act like a cocoon protecting the user from messy interactions with other humans, affective robotics can easily play into this tendency and this should be avoided.

Finally, affective robotics gives us the opportunity to discover interesting facts about the social psychology of friendship. While working to make our technology friendlier, we should pay attention and learn how to incorporate those findings into other technologies.

Affective robots will be successful only if they function as tools that enhance social bonding and cooperative behavior in the human lifeworld. They must not be used to replace real people or pets, but as a new addition to these existing relations they will be a welcome technology, and perhaps we will make some new friends in the process.

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