

The Mindset of Japanese Engineers within the field of Care Robotics - Robotics in Aging Japan

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1. Introduction

Japan is known for being a technology-loving country – a country of robots. Since the Meiji Restoration (1868-1912), change has been linked with technology. Due to the adaption of Western technology, it was possible to progress from a feudal state to an industrialised country. Furthermore, with the help of new technology, it was possible to not only repair the damages sustained during the war, but also to achieve extensive prosperity. This trend of using technology continued in the seventies with the large scale implementation of industrial robots. For this reason, it is not surprising, that Japan is called the “*Robot Kingdom*” (Schodt 1988).

Aside from technological advancements, there are other factors, mainly cultural, that can explain the Japanese penchant for robots. An early example is *karakuri*, which are mechanic dolls from the 17th century that were used to serve tea. Shintoism and modern pop culture, including anime and manga, have lead to a very relaxed environment for the development of robotics in Japan.

The Ministry of Economy, Trade and Industry (METI) itself has declared robotics as a key industry for the future (JETRO 2006). This, however, was probably primarily motivated by the issues associated with an overageing society. Not only Japan’s society getting older, but it also experiencing the longest life expectancy and on eof the lowest birth rates in the world. No efforts have been made to compensate for the aging population and because of complex relationships with foreigners throughout Japanese history, no reforms to the strictly regulated immigration laws are expected. Furthermore, the birth rate is also not likely to increase in the near future.

Against this background, it is not surprising that robots are discussed as a technical solution for a social problem and a strong incentive for the further development of robotics. Therefore, a broad discussion about the application

potential of service and entertainment robots has been taking place. This leads to a trend of new developments being considered quickly and without reserve. Robots are even being developed to interact directly with people, i.e. in nursing homes.

Even if there is a wide debate in the media, service and entertainment robots are still being developed and designed by universities, research institutes and companies. Here a particularly interesting aspect to explore is to what extent are these robots created and do certain factors, such as culture influence specific concepts.

There are only a few publications about the state of research regarding robots in Japan. The most famous is from the late eighties: Frederik Schodt's "Inside the Robot Kingdom". Schodt deals primarily with industrial robots in his publication. This is because the research field of service and entertainment robots did not exist at this time. In 2006, Timothy Hornyak the science and technology journalist, published his book "Loving the Machine", which refers to Schodt's content, but does not discuss industrial robots in detail. In contrast to Schodt, Hornyak emphasizes the latest developments in the field of entertainment robots. Both publications provide a solid overview on the state of research on Japanese robotics.

There are also a few other publications from English and German speaking countries which deal with the phenomenon of robots. Here Cosima Wagner should be mentioned, given that her focus is on the cultural aspects and use of robotic-assisted therapy (Wagner 2009a, 2009b).

Apart from the rather narrow literature selection in English and German, there are a variety of publications in Japanese, which should be introduced briefly as an overview of different approaches. Since the seventies, Masahiro Mori has been dealing with the effects of machine design on humans (Mori 1970). Hiroshi Ishiguro paid particular attention to humanoid robots and their interaction with humans (Ishiguro 2007, 2009). Takanori Shibata, the inventor of the robot seal Paro, is focusing on robot applications specialised for the elderly (Shibata 2007).

A detailed study of the mindset of Japanese engineers and researchers has not yet been conducted. The upcoming study is intended to fill this gap and shed light on Japanese robot development in detail.

2. History of Robotics

The term robot, as we use it today, goes back to the play *R.U.R.* (1920) by Karel Capek. His play was written when fascism and communism were gaining strength in Europe at the beginning of the nineteenth century. He derived the word robot from the Slavic word *robot*, which means labor or forced labor. The play is about machines that work for humans, but at some point start to revolt against their creators and eventually eradicate them (Capek 2009).

Religions with their own understanding of technology also have an impact on how robots are perceived. From a creationist religion's perspective such as Christianity, Judaism or Islam, the creation of artificial life is seen as competition with God. According to this understanding, the creation of a robot interferes with the divine order, which attracts punishment as consequence (Ichibiah 2005: 34). This could be one possible explanation for the fact that Europeans are only playing a minor role in humanoid robot development.

Literature and media were affected by Capek's robot term. In the past there have been many negative publications of robots, which in turn have influenced the present negative associations with robots. In current literature and media, robots are usually hostile towards humans or act destructively, which conforms to the above mentioned influence of Capek and religion.

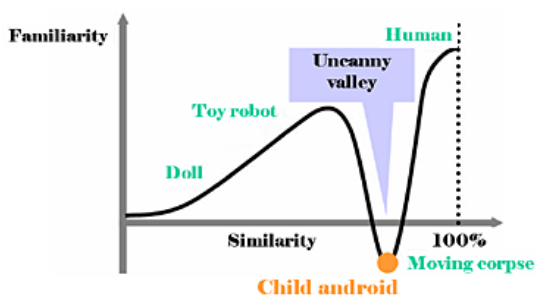
A few examples are the movies *Frankenstein* (1931) and *The Terminator* (1984). Capek's term *robot* has also been used by science fiction author Issac Asimov, but in his work they are viewed in a positive light, and had a huge influence on robotics with his robotic ethics (1938). His novels are about the issues which arise from his three laws of robotics:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws (Ichibiah 50-51).

This sophisticated and positive understanding of robots had a strong influence on science fiction literature during the last few decades. The book *I, Robot* by Asimov (1950) was adopted into a film of the same title in 2005 (Ichibiah 80~).

Originally, robots were something we would mainly associate with science fiction literature, but since the seventies they have become part of reality. With the progress of automation and, thereby, the development of industrial robots, a great number of autonomously acting machines have found their way into production. Joseph Engelberg and George Devol are said to be the inventors of the first industrial robot, Unimate. Devol recognized early that a large amount of tasks in fabric production consisted of simple mechanical actions and that these tasks could easily be automated (Schodt 1988: 30-35). The Unimate's design resembles that of a tank with an arm on top. Even today a lot of industrial robots are created with this arm-based design.

Due to industrial robotics, extensive mass production without a compromise of quality became possible and led to considerable economic growth in industrial nations. Despite these benefits, in Europe and the U.S., there is a fear that robots are replacing humans (Sone 2009). This fear results from a negative image of robots spread through the media and a working environment in which lifetime employment has become an exception. This negative view on robots presents an obstacle for the development and implementation of service and entertainment robots.



[Figure 1: The Uncanny Valley (IRL 2013)]

Already, in the seventies, Masahiro Mori started to pay attention to the effect of the appearance of machines and also robots and its effect on their acceptance by humans. His “uncanny valley” theory (Mori 1970) is still used today as an important criterion in robot

development. His theory states that the more closely a robot resembles a human in movement and form, the more likely it will be accepted; however, the acceptance does not infinitely increase. At a certain point, even if the similarity is continually increasing, the sense of familiarity will suddenly decrease and the design will be rejected by humans.

It's for this very reason that during the development process, a machine-like design is often chosen. This is not only the result of the influence of the media or religion; but

also by the fact that a lot of engineers, especially in Germany, think that functionality is more important than design (Gräfe 2010). This may be true for the industrial robots, but it is not applicable to service or entertainment robots, which are used in an environment with humans. In the field of service and entertainment robotics, acceptance is a key factor for the applicability of robots and in that context; the design determines the success of a specific robot.

Another factor may be the state of technology in the field of humanoid robots in Germany. Japan is the worldwide leader in the field of bipedalism and will not be overtaken any time soon. For this reason, Germany is avoiding direct competition through an alternative design approach. In Germany, some well known service robot projects are: Care-O-Bot, CASERO and HERMES.



[Figure 2: Care-O-Bot]



[Figure 3: CASERO]



[Figure 4: Hermes

<http://www.unibw.de/fir/roboter/hermes> (accessed 14.11.2014)]

2.1 Robotics in Japan

In contrast to Europe and the U.S., the development of robots in Japan is more geared towards a human-like appearance. The reason for this choice lies in a different cultural environment and understanding of technology. This different way of thinking is even more apparent when talking about the implementation of robots; especially when considering issues connected with demographic change. Here, among other factors, the declining working age population and the increasing number of people needing care has lead to a shortage of health care professionals and, therefore, an increased demand for

quick and feasible solutions for this labor shortage - here is where the application of robots is being considered.

Since the Meiji Restoration (1868-1912) technology has been connected to change. Through the adaption of Western technology it was possible to modernize the country in a very short period of time. Furthermore, after the loss of the Second World War, Japan was totally destroyed. Technology made it possible to rebuild the country and regain its prosperity. Since the seventies the bulk of the world's industrial robots have been used in Japan (Schodt 1988: 15-16) and to this day it's still a pioneer in the field of robotics.

Aside from the modernization and industrialization of Japan, Shintoism has had a great influence on the attitude towards inanimate objects, such as machines and robots. According to Shintoism, it is assumed that even inanimate objects have a soul with specific attributes. Therefore, there is a discrepancy between the Japanese and Christian understanding of an object's existence, where Christians believe only living creatures have autonomy and God is the sole creator of life.

In this context, the *karakuri* are another reason for the Japanese enthusiasm towards robots. *Karakuri* are machines or automats that can independently perform specific movements (Wißnet 2007: 19-34). During the Edo Period (1603-1868), they were invented using the basics of foreign watch technology. The Edo Period is remembered as a time of isolationism, during which nearly all trade and technology transfer was suspended for 200 years. The *karakuri* were an exception since they were allowed to be researched for entertainment uses. These mechanical dolls enjoyed great popularity at festivals and are still partly in use today.

Furthermore, robots play a special role in modern pop culture, especially in manga and anime. In Europe and the U.S., films like *The Terminator* and *Frankenstein* transmit a negative view on robots. In contrast to this, there is a positive view on robots in Japan, where robots are often portrayed as friends or seen as helping humans. Some examples of this are *Astro Boy* (1951-1968), *Doraemon* (1970-present), and *Mobile Suit Gundam* (1979-present).

Astro Boy is a manga written by Osamu Tezuka which depicts a story about a robot with a soul that wants to be as human as possible. The story often incorporates the positives and negatives of technology and their relation to humans, where *Astro Boy*

stands up for the humans and gets into complex and difficult situations (Hornyak 2006: 48-53).

It is important to note that Astro Boy was released right after the war was lost and a belief in reconstruction through technology was very strong (Schodt 2007:17-33; Kenji 2010: 69~). It could be seen as an analogy of Japan catching up with the West through technology during the Meiji Restoration.

Doraemon is another anime and manga character. The manga and anime are both still in production today after over 40 years. Doraemon is a 22th century robot from the future that assists its owner in various situations. Doraemon uses various futuristic tools that he pulls from his pocket, which sometimes makes the situation even more difficult for his clumsy master. In Japan and most of Asia, Doraemon enjoys a large popularity, which is similar to the popularity of Mickey Mouse in Europe and the U.S..

Mobile Suit Gundam (often referred to as just “Gundam”) is an ongoing Japanese anime series from the late seventies which has been adapted into many forms, including manga and movies. The story is about the war between human space colonies, developed due to the overpopulation of the Earth and their rebellion against the Earth for autonomy. Action is centered on gundams, giant robots that are used as weapons (Hornyak 2006: 61-69). Gundam is particularly popular among teenagers and young men.

These anime and manga have shaped a lasting positive image towards robots in Japan. They influence both the developers and the public attitude towards robotics. Overall, it is safe to say, that through the combination of specific cultural factors like Shintoism, karakuri and pop culture, a positive environment for the acceptance and development of service and entertainment robots exists. Therefore it is no surprise that robotics are put forth as an approach to solve problems that are associated with the demographic change (Nakayama 2006, NEDO 2009).

2.2 Robotics and Demographic Change in Japan

Due to cultural and economic changes in the early seventies, the birthrate in Japan began to fall under to a level of 2.1 children per woman (Ishii 2008). Currently the birthrate is around 1.3 children per woman and furthermore the population has declined slightly between 2005 and 2009. Forecasts state that the population will decrease by 25% by 2050. During the same period, the population over 65 years is expected to

increase from the current 20% to 40% (Atoh 2008: 18-19). As a result of the demographic change in Japan, it is assumed that it has led to a labor shortage in the field of elderly care.

Japan has to work out remedial measures to counteract the declining labor force and the shortage of nursing staff. This trend of dropping population can be alleviated by different social approaches. For example, the labour shortage can be balanced with a more lax immigration policy, allowing a greater number of qualified individuals into Japan. Also, having a higher percentage of women or older people in the working world would help alleviate the labour shortage as well. In particular, hiring qualified individuals from abroad will improve the healthcare and elderly care sector.

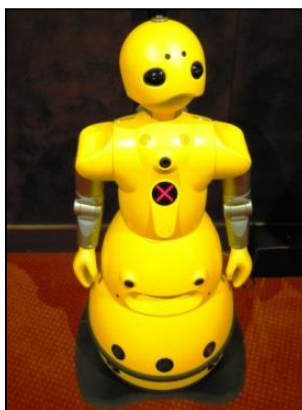
These social approaches aside, robots are also seen as a possible alternative. It appears that there is a tendency to lean towards technological solutions and less towards social reform. Japanese engineers and scientists have tried to design machines that resemble and move like humans for a long time. One known example that resembles a human is the bronze figure machine Gakutensoku that was introduced in 1928 at the World Exhibition in Kyoto by Makoto Nishimura (Hornyak 2006: 35~). Gakutensoku was able to change his facial expression and move his head and hands via air pressure, which allowed it to write words.

Industrial robots played a major role in the economic revival of Japan during the sixties. Instead of easing strict immigration policies to help with the shortage of labor, they introduced widespread automation through robotics - the very first industrial robot was put into operation during this time (Schodt 1988: 113-114). Thanks to an employment structure focusing on longterm success, there was no fear of labor replacement by robots. Instead of replacing them, workers were simply transferred to other working fields if their current field was replaced by robots.

The improvement of technology in the eighties helped the robots to become faster, more precise and more applicable, which led to their quick and broad extension. At this point 60% of the world's existing industrial robots were in operation in Japan (Schodt 1988: 15). Currently 36% of industrial robots worldwide are used in Japan, and 80,000 of the total 113,000 robot units built in 2008 were exported from Japan (Tanaka 2010). Japan is not only using robots to compensate for the decreasing labor force, but also to gain a foothold in the robotics market to acquire capital worldwide. The Japanese

government is providing substantial financial support for the development and research of robots. The METI has proclaimed robotics as one of the key industries that will get economic promotion in the future (JETRO 2006).

Japanese companies and universities, however, are not concerned with economically usable robots. They have focused their attention on the the development of robots that can act like humans or interact in a natural way with humans. Many engineers often refer to inspiring examples from manga and anime, especially *Astro Boy*. For them, their development objective is to create robots that look and act like humans. A few well known examples of anthropomorphic Japanese robot projects are the communication robot, wakamaru, the astronaut like robot, ASIMO, and the musician, Toyota Partner Robot series.



[Figure 5: wakamaru]



[Figure 5: ASIMO
<http://asimo.honda.com/gallery> (accessed 14.11.2014)]



[Figure 6: Toyota Partner Robot
http://www.toyota-global.com/innovation/partner_robot/family_2.html (accessed 14.11.2014)]

2.3 The State and Future of Japanese Robotics

Worldwide, the matter of elderly care and care in general is becoming increasingly important. Notably, Japan quickly and comprehensively needs to respond to its rapidly aging society.

In the study and development of assistive robotic technology, Japan has already been doing research for many years. An example is the research of Toshimitsu Hamada and Mitsuru Naganuma, who analyse the effects and benefits of robot assisted therapy. In their experiments they use AIBO and Paro in nursing homes to examine their effect on the elderly (Hamada et al. 2006). AIBO is a dog-like robot, which is able to interact

with his owner and be programmed through a remote control. Paro is a seal-like robot, which can communicate through sound and is used for therapy. On a similar basis as animal assisted therapy, it seems that by using Paro, it can help relieve stress and discomfort in the elderly (Shibata 2006). One advantage of robots in the field of health care is that there is no problem with hygiene regulations and the running costs and so, in comparison with a living therapy dog, costs are much lower.

Another Japanese robot that enjoys great media attention is the humanoid robot named RI-MAN developed by RIKEN. RI-MAN is equipped with visual, olfactory, auditory and tactile sensors (RIKEN BMC 2008). It has the ability to lift and carry people. RI-MAN is expected to be used in hospitals and nursing homes in the near future. The robot should relieve the physical burden of the nursing staff by moving people out of bed and into wheelchairs, and vice versa. RI-MAN's successor RIBA is a collaboration between RIKEN and Tokai Rubber Industries, who together established the RIKEN-TRI Collaboration Center for Human-Interactive Robot Research. The most noticeable difference to its predecessor is that its design was not inspired by a human but by a polar bear.

In Japanese society, the idea of using robots within the field of elderly care seems to be highly fixed. From an economic perspective, the government and many companies have invested huge amounts of money into robotics research. From an everyday perspective, families are looking for ways to facilitate the care of their aging relatives. Noriko Dethelfs and Brian Martin (2006) have examined Japanese politics on technology in the context of elderly care. They looked closely at the prospects of international standard technology, robot technology and barrier-free technologies, such as wheelchair ramps or stairlifts. The result of their research revealed that after considering the advantages and disadvantages a combination of the diverse options is the best strategy in terms of aging. It is often said that Japanese society is very robot friendly. Intercultural studies, however, indicate that the attitude towards robots in Japan might be more complex than assumed. A study by Bartneck et. al. (2005), shows that in many areas the acceptance of technology in comparison to other robot technology countries, such as China, the Netherlands and Germany, is not very different. In all measured categories Japan had an equivalent acceptance towards robots as Germany. In another study (MacDorman et al. 2009) conducted in universities in the U.S. and Japan, considerable differences

regarding the attitude towards robots were found. The most outstanding was that Japanese students seemed to be much more familiar with robots than students in the U.S..

In recent decades advanced technologies, such as automation and robotics, have made a substantial contribution to the successful development of Japan; and have assisted it in becoming a prosperous and economically strong nation. Therefore, it is no surprise that politicians, companies, and researchers are seeing technology as both a means of assuring international competitiveness and also to address social issues, such as labor and nursing staff shortages. A high-tech nation with a leading position in the field of robotics is additionally an important part of Japan's self-created image.

One of the most famous humanoid robots is ASIMO, which is manufactured by Honda. ASIMO is said to be one of the world's most advanced robots ever. According to the website for ASIMO, it is the result of two decades worth of research and has undergone a huge number of changes. The latest ASIMO is 130 cm tall and weighs 54 kg. Furthermore, he can walk, ride a bike, transport things and has 36 degrees of freedom (Honda 2011). Degrees of freedom refers to the number of freely selectable independent motion capabilities of a system. Through extensive travels by ASIMO to different countries, it has become an ambassador for Honda and advanced Japanese technology in general.

The aim of many engineers and researchers is to eventually create a robot that cleans, cooks and can take care of aging parents at home (MacLeod 2009). Junichi Takeno of Meiji University takes up the position that robots will be able to deal with complex social tasks and will be able to simulate human emotions one day (Tabuchi 2008). Hiroshi Ishiguro of Osaka University focuses primarily on the research of androids with the aim of developing robots that look confusably similar to humans (Ishiguro 2009). The main advantage of humanoid robots can be seen in the ease of usability in human-orientated environments. It is also natural for humans to deal with their own existence. In this sense, robots serve as a kind of mirror (Ishiguro 2009). Ishiguro's most famous robot is the Geminoid, which has been designed according to Ishiguro's own physical model. The Geminoid is a remote-controlled robot used to communicate and work, much like a human sized cell phone. Furthermore, the robot has body functions such as breathing and facial expressions created by a hydraulic system. This leads to the

impression that it is a proper human being. One research article on the Geminoid demonstrated that the distinction between humans and Geminoid is very difficult (Bartneck et al. 2009). Other developers are seeing robots as walking computers that respond only to voice commands and can follow their users in their home environment. Overall, there is a greatly diversified robot research landscape in Japan and regarding the direct human-robot interaction the perceptions are open-minded. The origins of this can be found in the positive cultural environment where there are few reservations towards technology and robots.

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