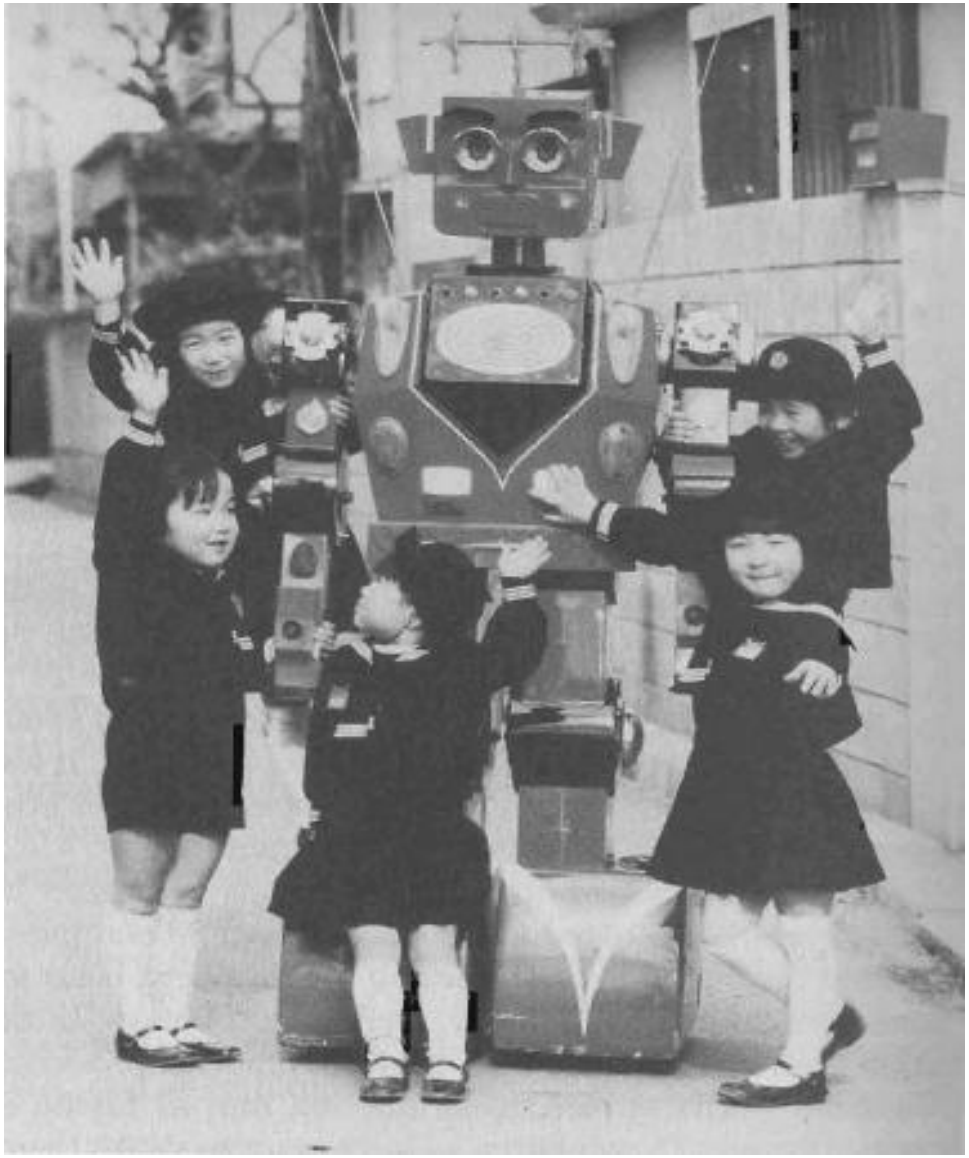
INSIDE THE ROBOT KINGDOM

Japan, Mechatronics, and the Coming Robotopia

Frederik L. Schodt



School children with a remote-control play robot made by inventor Jiro Aizawa

Robots in Japan

20 years ago
http://www.youtube.com/watch?v=FYPlmZ4xgMM

landwalker
http://www.youtube.com/watch?v=oVwbUljGs3g

robot show
http://www.youtube.com/watch?v=V3eeQK5YAmo

robot carp
http://www.youtube.com/watch?v=M7YGEVuJ4mM

motoman taiko drums
http://www.youtube.com/watch?v=kkD26CQpDDo

Karel Capek: R.U.R. (Rossum's Universal Robots)
written in 1920, premiered in Prague 1921

Plot summary

In R.U.R., the idealistic young Helena Glory arrives at the remote island factory of Rossum's Universal Robots, on a mission from a humanitarian organization devoted to liberating the Robots. From Domin, she receives a compressed account of the company's father-and-son founders . The mad inventor Old Rossum was bent on usurping the role of the Creator by artificially reproducing a man in painstaking detail, while the practical industrialist Young Rossum produced a stripped-down version of humanity to be sold as inexpensive workers.

Mass-produced by Robot-run assembly lines, Robots remember everything, and think of nothing new. Rejecting Helena's theory that Robots have souls, the psychologist Hallemeier admits that once in a while, a Robot will throw down his work and start gnashing his teeth. The human managers treat such an event as evidence of a product defect, but Helena prefers to interpret it as a sign of the emerging soul.

The scientists modify some Robots, so that their souls might develop more fully. One of the modified creatures is a Robotess, beautiful but useless. The scientist speculates that if the Robotess “Helena” were to "wake up," she would hate him for making her so beautiful, yet giving her a body that cannot know love or give birth. The human Helena begins identifying with hothouse flowers -- sterile because they are artificially cultivated, satisfying a consumer demand that nature fulfils too slowly on her own.

One of Helena's specially modified Robots issues a manifesto: "Robots of the world, you are ordered to exterminate the human race. . . Work must not cease!" Domain possesses Old Rossum's formula for producing Robots -- a bargaining tool he hopes to use to ensure the freedom of the humans holed up in the factory. Helena, who has been kept ignorant of the real threat the Robots propose, decides to burn the formula, on the theory that halting the production of the Robots will halt the spread of economic and political collapse. The Robots swarm onto the stage, killing all the humans, leaving only Alquist -- the only human at the factory who still works with his hands. The Robot leader Damon plans to populate the earth: "We will give birth by machine. We will build a thousand steam-powered mothers. From them will pour forth a river of life. Nothing but life! Nothing but Robots!"

The Robots discover, however, that "the only thing we cannot produce is Robots. The machines are turning out nothing but bloody chunks of meat." They cajole, threaten and beg Alquist to help them discover what they call "the secret of life." In desperation, Damon offers himself up for study; screaming on the dissection table, he orders Alquist to continue the search.

In the end, two robots (the beautiful but otherwise useless Helena, and Primus) fall in love. The play ends on an uplifting, religious note. Alquist blesses the lovers, renames them Adam and Eve, and sends them out to avoid the sins that destroyed their predecessors.

INSIDE THE ROBOT KINGDOM

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Science fiction robots began appearing in Japanese literature shortly after the Tokyo performance of Karel Kapek's R.U.R in 1924, but they did not capture the public imagination the way they did in the West.

Before World War II, most robot science fiction in the West adhered to the formula "man makes robot, robot kills man." In Japan, the most popular robot stories and characters have been visual and emerged mainly from post-war comics and animation. As a result they have also had far greater influence.

Since 1963 more than one hundred serialized robot animated shows for television... have been produced. Unlike the humble *karakuri* dolls of feudal Japan, these imaginary robots are an exuberant assertion of a collective technological fantasy.

Early Robot: Tanku

One of the first pre-war "robot" characters in Japan was Tanku Tankuro, the hero of a children's comic story (with the same name) created by artist Masaki Sakamoto in 1934.

Tanku's human head sat atop a cast iron body that looked like a bowling ball with eight holes. He operated on What seemed to be magic, and readers never knew what he would pull out of the holes in his body. Sometimes he waved swords or guns, at other times he sprouted wings and a propeller and transformed into an airplane or even a tank.
He was drawn in a naive style and given an endearing personality, and when he fought he was always on the side of good (Japan). Often he was involved in wars, which reflected the climate of the times.

Tanku as airplane

Robots after World War II

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Since the end of isolation, Japan had pursued a policy of *fukoku kyohei,* or "rich nation, strong military." To avoid being swallowed by the colonialist powers of the West, It tried to catch up to them on all levels of technology, especially military might. In the process, militarists gained control, and Japan (emulating the West) embarked on an imperialist course in Asia, in the 1930s becoming embroiled in a war China that eventually led to the disaster of World War II.

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The most famous Japanese robot character of all time appeared in an utterly different social environment after World War II, when comics were beginning their explosive growth in popularity, when militarism was replaced by an ideology of peace, and when science and technology took on a civilian significance. Tctsuwan Atomu, or *Mighty Atom* as he was called, was created by a young medical student/artist named Osamu Thzuka in 1951.
He proved so popular that he went on to be serialized for eighteen years as a comic book story, starred in Japan's first animated series for television in 1963, and was then exported under the name *Astro Boy*.

ATOM: machine as hero

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Atom was a little boy robot in a normal family -of other robots-who went to a normal school with real human children, but unlike them he had a nuclear reactor for a heart, a computer brain, search light eyes, rockets in his feet, and a machine gun in his tail. Instead of waging war, he fought monsters and bandits in the name of peace. He became one of the most popular fantasy heroes ever, and his image -that of an android robot with feelings that helped man- was permanently etched into the national consciousness. Japanese children had discovered a new hero: the machine.

In 1986 Tezuka explained that he created Atom to be a type of twenty-first-century reverse Pinocchio, a nearly perfect robot who strove to become human, and also to be an interface between two different cultures-that of man and of machine.

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Atom became the little boy next door, except he lived in the future where science and technology had created a world of clever gadgets: a standard of living that Japanese could only dream about. Atom -and robots- became linked with a wonderful future that science and technology could provide.

Osamu Tezuka's Mighty Atom, showing his atomic reactor, computer, search-light eyes, and other attributes. © 1950 O. Tezuka.

Iron Man 28

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In 1956, soon after Tezuka began drawing Atom, another artist named Mitsuteru Yokoyama created a rival series starring a robot of an entirely different nature. Called Tetsujin 28go, or *Iron Man No. 28*, he, like Atom, could fly through the air (with rockets on his back). But he was actually a step backward technologically. A giant metal monster (20 meters tall and weighing 25.08 tons), his main power was his brute strength, used to kick and punch in fights. Instead of being an autonomous android endowed with artificial intelligence, he was operated by a remote-control device. Usually this was in the hands of Shotaro Kinta, a young boy "private detective" who used Iron Man to foil nefarious criminals of various sorts. If the device was stolen, Iron Man could be employed for evil ends as well. He was, in a sense, much closer to today's industrial robots than Atom. He was neither good nor bad; he was only a machine.

Iron Man 1966

Iron Man 2007

Asimov's Three Laws of Robotics, presented in 1942

1. A robot may not injure a human being, or through inaction, allow human being to come to harm.
2 A robot must obey the orders given 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 Law.

Osamu Tezuka's Ten Principles of Robot Law from the *Mighty Atom* series:

1. Robots are created to serve mankind.
2. Robots shall never injure or kill humans.
3. Robots shall call the human that creates them "father."
4. Robots can make anything, except money.
5. Robots shall never go abroad without permission.
6. Male and female robots shall never change roles.
7. Robots shall never change their appearance or assume another identity without permission .
8. Robots created as adults shall never act as children.
9. Robots shall never assemble other robots that have been scrapped by humans.
10. Robots shall never damage human homes or tools.

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Atom had seven special powers, such as the ability to speak over sixty languages, but unlike the magical powers of American superheroes or earlier fantasy robots in Japan, they were all based on what seemed to be scientific electromechanical principles. Schematics of Atom's body were published, showing a maze of wires and circuitry. Sometimes he would be damaged or malfunction and have to be repaired.

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...Japan had lost the war because of overconfidence and because "our armed forces put too much emphasis on the spiritual side and forgot science." Even the antiwar Tezuka was affected. "I realized very clearly that Japan lost the war because of science and technology," he says today. "While the US was dropping atomic bombs the Japanese military were trying to light forest fires in America by sending incendiary balloons made of bamboo and paper over on the jet stream. We developed an inferiority complex about science and technology."

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Atom and Iron Man are the ancestors of all subsequent Japanese fantasy robots, particularly two distinct genres seen today: autonomous robots and those that require human intervention for their operation. In this sense they parallel laboratory research trends that aim at developing advanced robots which operate on their own or by remote control.

Doraemon Pet Robot

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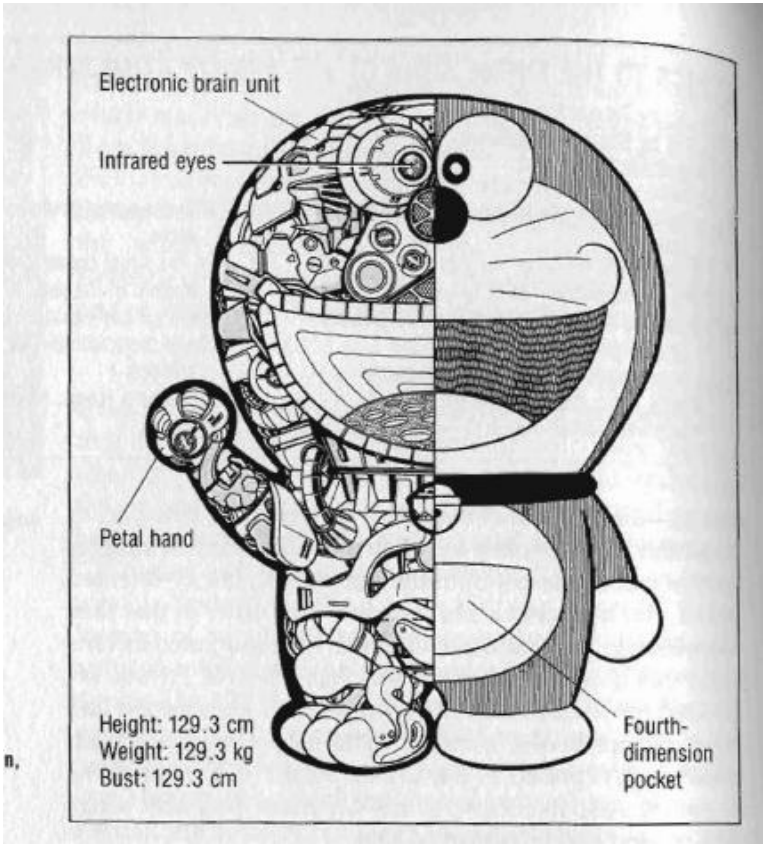
A cute, endearing robot cat, Doraemon lived with a young boy named Nobita in a normal family setting, having materialized in Nobita's desk drawer one day after being sent through the fourth dimension from the twenty second century. Nobita was rather clumsy and a poor performer in school, so much so that he had created great problems for his descendants. To correct this, his great-great grandson sent him Doraemon, a robot cat that children of the future used as guardians.

By 1985 fifty-five million copies of the story had been sold in paperback form; the series had been animated for television and theatre. Doraemon dolls and toys were everywhere. In a country where space is at a premium and where animals have traditionally been few and far between, Doraemon symbolized a popular fantasy among Japanese young children
- the little robot as pet.



Doraemon was created by artist Fujiko-Fujio in 1970.

Arare - chan: Girl Robot

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The same thing occurred with Arare-chan, a little girl android robot created by artist Akira Toriyama in 1980. Arare-chan achieved that rare status all creators of fantasy hope for; a character so popular it appeals to people of all ages and both genders.
In the original story, Arare-chan was created by a slightly dingy inventor named Dr. Slump. Arare-chan looked like any other little girl, except that she would occasionally take her head off at the wrong time and had difficulty controlling her herculean strength. Her appeal lay in her funny mistakes, her cuteness, and the weird world of her inventor.

Warrior Robots: The Man - Robot Symbiosis

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The most famous, original, and prolific type of fantasy robot character in Japan is the giant warrior robot. The vast majority of these are the descendants of Iron Man No. 28 and require human intervention for their operation.

...There remained one element to finalize the giant warrior robot *genre-henshin,* or transformation, a popular ingredient in Japanese fantasy. In Japanese myths, foxes, and cats, transform into beautiful women, and ninja warriors often transform into other entities to foil their enemies. In comics, Shotaro Ishimori, in particular, had created many popular characters in the 1960s and 1970s who switched from one form to another, and often they were robots.

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...The plots of the giant warrior shows adhere to a simple formula. A young boy is leading a normal life, when giant robots attack, threatening the destruction of the world. Usually the boy's parents are killed, but before dying his father, who is a top scientist, hands him the keys (or blueprints) to a secret weapon he has been building - a giant robot more powerful and technologically sophisticated than anything else. Then the plot degenerates into fights between robots and monsters...

Transformers (2007): Optimus

Robots and Religion in Japan

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Most statements about religion and robots are inspired by Japan's tradition of animism. Animism is the belief that everything in the natural world -not just living things- have a conscious life or soul. It exists in Buddhism but is especially strong in Shinto. Shinto is indigenous to Japan and while over the millennia it has been overlaid with foreign deities, nationalism, and emperor worship, at its core is a form of nature worship and the belief that inanimate objects can be sacred. Mountains, trees, even rocks are worshipped for their *kami,* or indwelling "spirit," and samurai swords and carpenter's tools have "souls." Gods of local industries, such as rice growing, paper making, ceramics, and weaving, are also still worshipped today.

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Religion is also invoked in another context with industrial robots. Even if Buddhism and Shinto contain nothing that intrinsically promotes robots, the argument goes, they contain nothing to hinder them, whereas Christianity does. Since Japan is dominated by the former, it must have less resistance to robots....

Robots and Buddhism

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Robots are tools, which may in part explain why the Japanese often seem to treat them rather special. The word *dogu,* meaning "tool" was originally a Buddhist term. In early religious literature, it was used for something that aided one in pursuing the path of Buddha's teachings and could refer to religious clothing or articles used in religious rituals. Later, the word took on a more active meaning and was applied to tea ceremony implements, weapons used by samurai, and tools for production.

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The famous roboticist Mori came to believe as a result of his studies that "to learn the Buddhist way is to perceive oneself as robot." And conversely, as he later articulated in his book *The Buddha in the Robot: A Robot Engineer's Thoughts on Science and Religion,* he came to believe that "robots have the Buddha nature within them; the potential for attaining Buddhahood."

Robots + Industrialization

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Any real test of the Asimov Frankenstein Complex (man creates robot; robot kills man) can only come in the distant future when and if working robots assume human form. It is reasonable to assume that the reaction to such robots will be more strongly negative in the West than in Japan. Christianity, after all, does assert the superiority of man over the rest of the natural world.

In Europe, the industrial revolution occurred when class systems were rigidly entrenched. It caused enormous social disruption, unemployment, and suffering among the lower classes.
Japan, on the other hand, escaped many of the negative aspects of the industrial revolution. Because it was isolated from the world during this period, machines were introduced later, as developed technologies, during the middle of the 19th century. This was a time of social ferment when the 4-tier class system of warriors, farmers, craftsmen, and merchants was already in collapse. All the institutions of government, economy, and industry were in flux.

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“We have had no history of people being victimized by machines; to most, machines have brought only good. In Japan today there is therefore absolutely no psychological resistance to them."

My Robot

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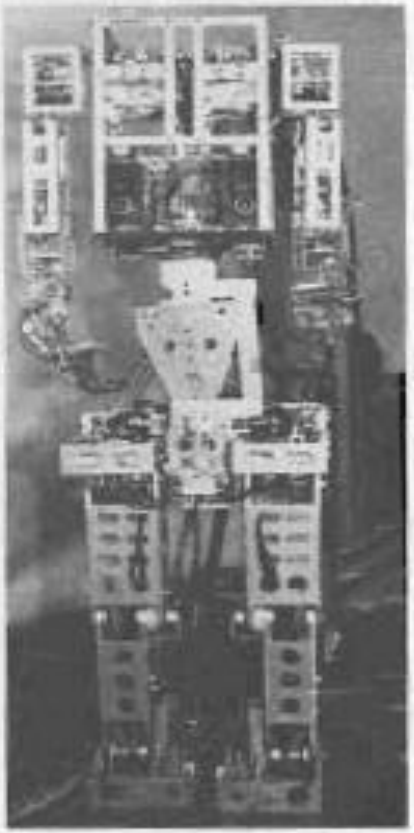
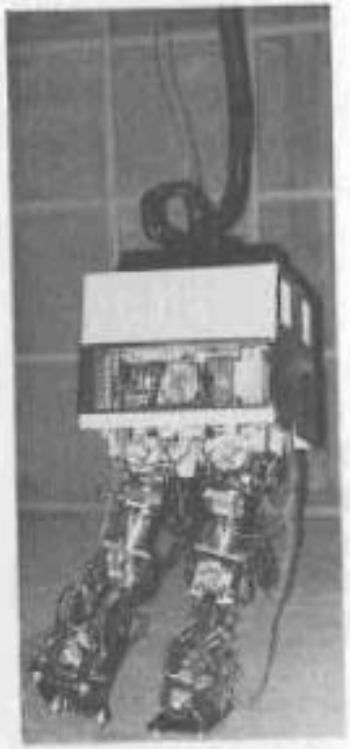
Kato believes that machines can be divided into three categories or phases. The first emphasizes movement and power. Most machines we see today, including industrial robots, fall into this category. The second category emphasizes information and includes computers. The third category, now on the verge of appearing, emphasizes information, intelligence, and power. The "My Robot," or personal robot, Kato says, will emerge as a machine of the third category to satisfy a long-standing desire of humans for a slave-like mechanical man. Far more advanced than the personal robots advertised by toy or hobby kit manufacturers today, it will be closer to the robots of science fiction. My Robot will take the form and size of a Japanese person, and one of the first places Kato foresees its use is in health and human services...
...instead of creating robots to replicate men, he is augmenting men with robotics, making cyborgs, or cybernetic organisms. In the very distant future, he believes that we will have a pluralistic cybot society consisting of humans, robots, and cyborgs.

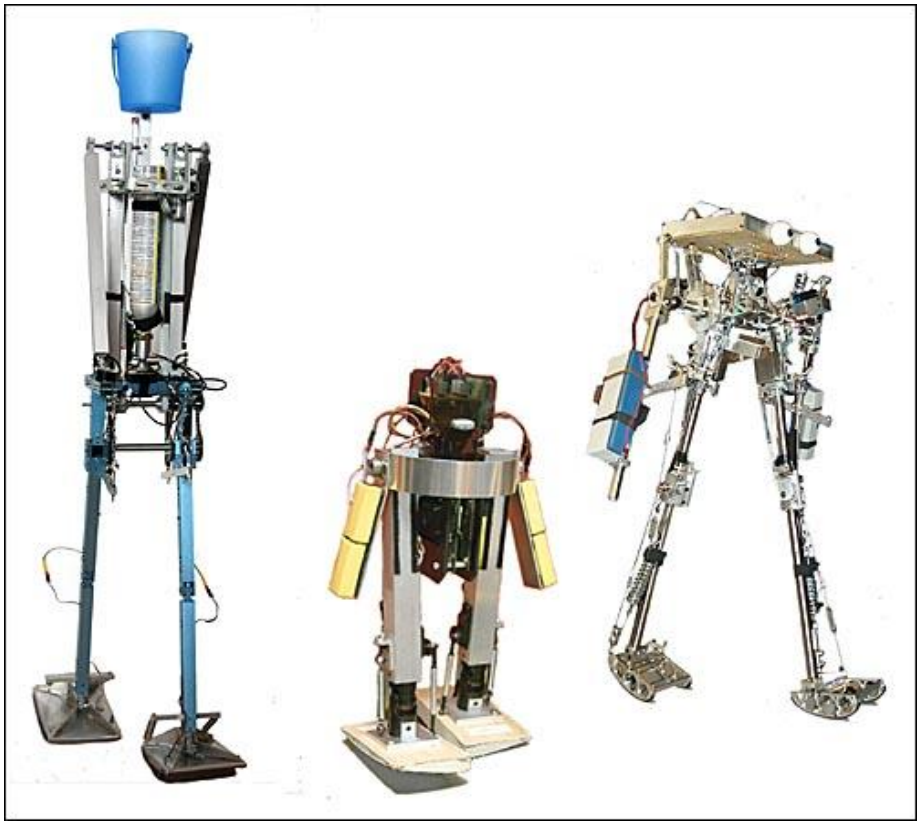
Ichiro Kato



WABOT 1, 1973, was the first serious full-scale anthropomorphic robot in the world. With legs, hands, artificial vision, and speech synthesis, it was claimed to have the mental ability of a one-and-a-half-year-old human.



WL-10 RD, a dynamic walker, with a claimed speed of 1.3 seconds per step.



Generating Natural Motion in an Android by Mapping Human Motion

Daisuke Matsui*, Takashi Minato*, Karl F. MacDorman†, and Hiroshi Ishiguro

Abstract

One of the main aims of humanoid robotics is to develop robots that are capable of interacting naturally with people. However, to understand the essence of human interaction, it is crucial to investigate the contribution of behavior *and* appearance. Our group's research explores these relationships by developing androids that closely resemble human beings in both aspects. If humanlike appearance causes us to evaluate an android's behavior from a human standard, we are more likely to be cognizant of deviations from human norms. Therefore, the android's motions must closely match human performance to avoid looking strange, including such autonomic responses as the shoulder movements involved in breathing.

This paper proposes a method to implement motions that look human by mapping their three-dimensional appearance from a human performer to the android and then evaluating the verisimilitude of the visible motions using a motion capture system.

http://www.youtube.com/watch?v=MY8-sJS0W1I

Introduction

Partner robots generally adopt a roughly humanoid appearance to facilitate communication with people, because natural interaction is the only task that requires a human-like appearance. In other words, humanoid robots mainly have significance insofar as they can interact naturally with people. Therefore, it is necessary to discover the principles underlying natural interaction to establish a methodology for designing interactive humanoid robots.

A robot that closely resembles humans in both looks and behavior may prove to be the ultimate communication device insofar as it can interact with humans the most naturally. When we investigate the essence of how we recognize human beings as human, it will become clearer how to produce natural interaction. Our study tackles the appearance and behavior problem with the objective of realizing an android and having it be accepted as a human being.

Fig. 2. The developed android "Repliee Q2"

Fig. 3. Examples of motion and facial expressions

Mori described a phenomenon he termed the “uncanny valley” , which relates to the relationship between how human-like a robot appears and a subject’s perception of familiarity. According to Mori, a robot’s familiarity increases with its similarity until a certain point is reached at which slight “nonhuman” imperfections cause the robot to appear repulsive. This would be an issue if the similarity of androids fell into the chasm. (Mori believes mechanical looking humanoid robots lie on the left of the first peak.) This non-monotonic relationship can distort the evaluation proposed in existing studies. Therefore, it is necessary to develop a motion generation method in which the generated “android motion” is perceived as human.

This paper proposes a method to transfer human motion measured by a motion capture system to the android by copying changes in the positions of body surfaces....

The Android

The *Repliee Q2 ...* android resembles an Asian woman because it is modelled after a Japanese woman. The standing height is about 160 cm. The skin is composed of a kind of silicone that has a humanlike feel and neutral temperature. The silicone skin covers the upper torso, neck, head, and forearms with clothing covering other body parts. Unlike Repliee R1 silicone skin does not cover the entire body so as to facilitate flexibility and a maximal range of motion. The soft skin gives the android a human look and enables natural tactile interaction. To lend realism to the android's appearance, we took a cast of a person to mold the android's skin. Forty-two highly sensitive tactile sensors composed of piezo diaphragms are mounted under the android's skin and clothes throughout the body, except for the shins, calves, and feet. Since the output value of each sensor corresponds to its deforming rate, the sensors can distinguish different kinds of touch ranging from stroking to hitting...The android is driven by air actuators that give it 42 degrees of freedom (DoFs) from the waist up. (The legs and feet are not powered.)

TABLE I

THE DOF CONFIGURATION OF REPLIEE Q2

	Degree of freedom
Eyes	pan×2 + tilt×1
Face	eyebrows×1 + eyelids×1 + cheeks×1
Mouth	7 (including the upper and lower lips)
Neck	3
Shoulder	5×2
Elbow	2×2
Wrist	2×2
Fingers	2×2
Torso	4

Transferring Human Motion

To create movement that appears human, we focus on reproducing positional changes at the body's surface rather than changes in the joint angles. We then measure the postures of a person and the android using a motion capture system and find the control input to the android so that the postures of person and android become similar to each other.
We use a motion capture system to measure the postures of a human performer and the android. This system can measure the three-dimensional positions of markers attached to the surface of bodies in a global coordinate space.

Fig. 6. The marker positions corresponding to each other

Fig. 11. The generated android's motion compared to the performer's motion. The number represents the step.

Experimental results and analysis

While we can recognize that the android is making the same gesture as the performer, the quality of the movement is not the same.

Although physical limitations cannot be overcome by any control method, there are ways of finessing them to ensure movements still look natural. For example, although the android lacks the opponent musculature of human beings, which affords a variable compliance of the joints, the wobbly appearance of such movements as rapid waving, which are high in both speed and frequency, can be overcome by slowing the movement and removing repeated closed curves in the joint angle space to eliminate lag caused by the slowed movement. If the goal is humanlike movement, one approach may be to query a database of movements that are known to be human-like to find the one most similar to the movement made by the performer, although this begs the question of where those movements came from in the first place.

We have not dealt with the android's gaze and facial expressions in the experiment; however, if gaze and facial expressions are unrelated to hand gestures and body movements, the appearance is often unnatural, as we have found in our experiments. Therefore, to make the android's movement appear more natural, we have to consider a method to implement the android's eye movements and facial expressions.

sumo robots
http://www.youtube.com/watch?v=7OWopN7Wysg

paro
http://www.youtube.com/watch?v=SAtcuoDjUUQ

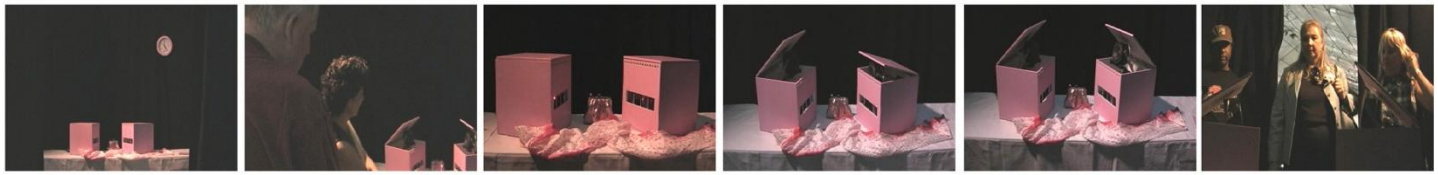
snake robot
http://www.youtube.com/watch?v=k-VgI4wNyTo

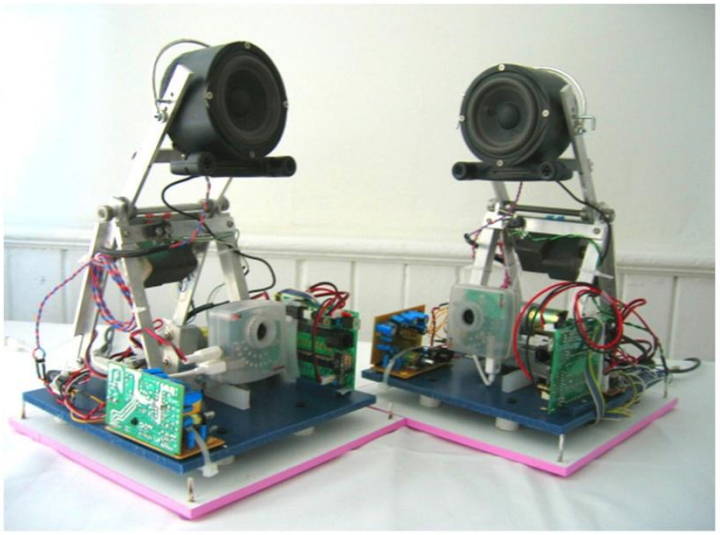
household robots
http://www.youtube.com/watch?v=yIdqh8GdOJg

sony dancing robots
http://www.youtube.com/watch?v=9vwZ5FQEUFg

androids
http://www.youtube.com/watch?v=Ig7qmddOq4s

Amy and Klara





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www.realtechsupport.org/new_works/male-dicta.html