Building Artificial Life for Play

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Abstract Playthings are often engineered to replicate the character of real organisms. In the past, inventors lavished great expense on their lifelike automata, their constraints being typically related to the mechanical technology they employed and the amount of time and effort they were able to commit to the enterprise. The devices that are currently produced are usually intended for the mass market. The cost of production therefore is a major concern, even though the technology is more sophisticated and highly automated than in the past. Consequently, toymakers and engineers, as well as artists, of the past and present alike have had to think abstractly about living systems in order to construct their simulacra economically. This essay examines a number of lifelike toys to discover the properties of real organisms that their designers have attempted to recreate. That we, as users of these devices, so readily recognize in them a degree of lifelikeness demonstrates the extent to which intuition may sway our intellectual reasoning about real biology. As a result, an innovative toymaker or artist is able to manipulate us to zoomorphize even the most extreme abstractions—at least momentarily—despite our rational reluctance to accept the trickery.

Keywords
Aibo, android, Tamagotchi, virtual pet, toy

1 Introduction

As children we may have played with plastic farm animals, toy soldiers, talking or crying dolls, wind-up beetles, or battery operated robots. Today's children laser-blast virtual alien life forms or pilot leggy, busty, machine-gun toting women through dangerous mazes—the idea of simulating the appearance and behavior of living systems has been with us our whole lives, even if a label for it has not. In fact, throughout history replicas of life have been widely produced. As in archaeology, the construction and character of such artifacts may inform us regarding the way we perceive and interact with simulacra of life from day-to-day.

Some ancient cultures, such as that of the Aborigines of Australia, attribute great power and life-spirit to painted images of living things. Others, such as the Yoruba of Western Africa, speak of their creators as potters, literally shaping life from clay and breathing spirit into their sculptures. This is not such a stretch from the medieval conception of the Golem of Prague, fashioned from clay and having the mystical word of life given to him by his Kabalistic creator. In the West, those who followed science may have followed Descartes' insistence that living things were clockwork or mechanical automata. This view being out of date, there are some now who insist that computer software may "live."

The history of technological innovation has brought with it more and more sophisticated replicas of life. Some of these were created for religious reasons or as philosophical puzzles, others purely for the amusement of an audience or their maker. Some were created as demonstrations of craftsmanship, to win fame, or as part of scientific investigations into biology. Regardless of the reasons for their creation, these devices are useful in allowing us to place in perspective our current interest in digital computing machinery and living systems. They highlight, too, how intuitively we respond to an artifact's particular lifelike traits, regardless of its other characteristics. In particular, this is true of toys and more sophisticated artifacts built for amusement. It is these that form the subject of this essay. Therefore, this essay will glance at a few examples of early clockwork automata and proceed to examine some current toys and artworks that are, by their nature, more visceral than most artificial life software developed for research.

Vaucanson may be known to artificial life researchers for his famous automaton duck. By this he aimed to demonstrate that all actions necessary for eating, drinking, and digestion had been exactly imitated [17]. In 1738, the inventor exhibited an automaton flautist to the Royal Academy of the Sciences in Paris. While other automata existed that played keyboards, beat drums, or rang bells, Vaucanson wanted his automaton to mimic a human playing a complex wind instrument—he wanted it to *breathe* [18, pp. 19–23]. Not only this, he wanted it clear that his automaton was a breathing *sculpture*, and to this end its shell replicated the design and patina of a marble figure by the French sculptor Coysevox [17]. Automata produced by Vaucanson not only mimicked the ability of a human musician, they surpassed it in speed and accuracy, calling into question the assertion that humans were somehow superior to machines in the realm of musical performance at least.

Since no recordings of the android flautist exist, it is difficult to judge how expressively it played. This was not Vaucanson's aim, however. He wished to "imitate by Art all that is necessary for a Man to perform in such a case," and he reveled in the ability of one of his flute-playing androids to perfectly tongue a bar of semi-quavers at speed, outdoing all human performers on the instrument. Reports of the day were favorable. The android played the German flute "with an exactness which has deserved the admiration of the public and of which a great part of the Academy has been witness" wrote the secretary of the French Academy. It "imitates a true player on the flute so perfectly" and is "one of the most wonderful productions of art" [17]. Vaucanson won considerable fame along with the title "modern Prometheus." Although it was possible for a machine to "breathe" air and, in the eyes of the Academy and general public of the time, play the flute as well as a human, could it match humans in intelligence? The question remained open.

The chess-playing Turk pseudo-automaton of Wolfgang von Kempelen, constructed in 1769, was intended to "demonstrate" to the public that artificial intelligence had been created in concert with mechanical life [5]. This device played chess as well as the leading players of the time. In fact, the leading players of the time were hired to sit inside the machine and trick its audience. The ability to play a competent game of chess has long been considered a trait of an intelligent mind. What did it mean for human intelligence if what seemed to be a mechanical automaton could beat all comers at their own royal game? Machines that breathed and played music or that won at chess seemed to be evidence in favor of Descartes' hypothesis that lower animals were nothing more than complex automata. However, it pressed the point that perhaps humans too were no more than complex machines. Worse still, it seemed that aspects of humankind could be improved upon using modern technology.

At a time when clockwork androids were appearing in droves, Jacquet-Droz built a writing automaton that, on occasion, is said to have scrawled Descartes' dictum, "I think

therefore I am," and followed this with, "I do not think... do I therefore not exist?" [8, p. 7]. Despite the flaws in the "reasoning," by inviting viewers to ponder the validity of its remarks, Jacquet-Droz's automaton served as more than a trifling amusement for the wealthy. This machine did not play music or chess. Unsettlingly, it was reproducing the words of one of the period's leading thinkers. Did it have a soul? How could a viewer tell? One day, would an artificial device be able to communicate with a human directly in this manner?

Regardless of the current views we hold about life, its imitation, and its synthesis, the lines we draw in the sand today may be washed aside by the tides in the morning—what remains of benefit is the act of questioning our views and reassessing our beliefs, and for this the toys and puzzles of the past serve as well as those of the present. The subjects of the remainder of this essay therefore are toys of the last few years and the particular aspects of living systems they highlight. The toys have been selected largely according to personal preference with an eye to exploring a wide range of devices and the diverse characteristics of the organisms they mimic.

2 Mechanical Movement in Physical Toys

The expense lavished on the creations discussed above was quickly recouped through charging society's elite admission to see them in operation. In contrast, since the assembly-line production of Edison's talking doll, mass-produced modern toys must be relatively inexpensive if they are to sell and recoup the cost of their design, marketing, manufacture, and distribution. For this reason, toymakers are often forced to economize. Such economic concerns, as well as concerns about the feasibility of mass production, have led toymakers to think abstractly about life and to produce simple devices to re-create or represent it. Thinking abstractly about living systems is something at which some artists also excel. It therefore comes as no surprise that the work of artists and toymakers in constructing replicas of life parallels the thinking of artificial life researchers to some extent. In the case of toys and art both new and old, the goal of the maker has frequently been to mislead the human owner or viewer of the artifact into believing the device is more complex than it really is.

While the artifacts mentioned in the section above focus our attention on mimicking outer signs of the inner workings of living creatures, the examples in this section focus on our perception of a creature's movement. In these cases, many other details of the creature's behavior have been abstracted away.

We will start the discussion with a wind-up toy called the Bonga from Kikkerland (Figure 1). The clockwork artificial life toy is no longer a novelty; such automata have

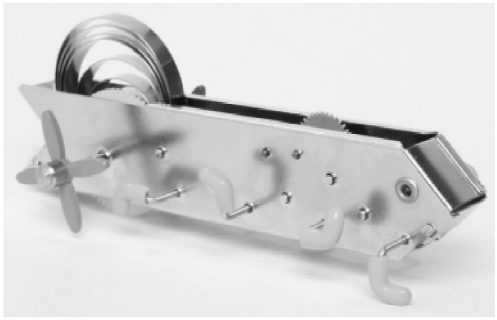

Figure 1. The wind-up Bonga.

been playthings of children for many years. What makes the Bonga interesting is the absence of *dressing*. Although in bodyplan it resembles a centipede and its wire legs are bent to make them look a little like miniature gum boots, very little effort was invested in decorating it to give the appearance of an animal. The Bonga is a bare metal box with eight plastic-capped rotating wires for locomotion. Its gears and steel spring are clearly visible. The only additions to the structure that serve no practical purpose are the rivet at the front and the cutout in the tail. The rivet seems to stand in for an eye. The cutout may be for aesthetic value, or to economize on cutting the steel side plates from a single strip end-to-end. Apart from this, Bonga is a walking machine, and that is all.

Watching it force its way clumsily over obstacles and across table-tops, however, one can't help but feel it is a determined little creature. The toy gets exhausted when its spring winds down, and it flails its legs wildly and helplessly in the air when it capsizes. Yes, this language is emotive, herein lies the fascination with the toy. Despite its undisguised mechanical nature, for humans the Bonga in motion elicits similar responses to a wandering beetle or perhaps a lizard. Would we take a hammer to it and violently crush it? A discussion of this issue appears in [7], which suggests we would probably find this behavior distasteful: the creature would seem so "helpless;" it would "writhe about in pain." It is easy for us to attribute determination to live to this little mechanical device. This may stand in our way if we should try to put a violent stop to its antics.

The toy snakes made of about ten hinged sections of plastic tube (Figure 2) connect us psychologically with the natural world for similar reasons to those initiated by the Bonga. In contrast to the Bonga's unadorned shell, typically these serpentine toys have plastic heads, eyes, and colored spots on their bodies in order to approximate the appearance of an animal. Such dressing is unnecessary. It is the movement and simplicity of the artifact that make this a perennial favorite. The sickly smooth slithering of the snake is unmistakable, even when recreated in bright shades of plastic and even though the device is not autonomous but depends on the human hand to bring it to life.

Whereas Bonga and the toy snake depend on our visual senses to recognize their lifelike movement, two Dutch artists, Erwin Driessens and Maria Verstappen, have created devices that caress humans. Due to the intimacy of physical contact, the sense of being touched by a living creature is even more powerful than that experienced when watching one move. How many of us have been paralyzed by fear as a wandering insect or spider touched us as we lay in bed at night? Tickle and Tickle Salon have won first prizes at the international artificial life art competition LIFE 2.0 / 1999 and 5.0 / 2002 respectively. Tickle is a small mobile robot with two motors, rubber caterpillar tracks, and a set of sensors to detect slopes and thereby remain on a person's back as it maneuvers around at 1.2 cm/sec (Figure 3). The controller for the robot is implemented as a hardware finite state machine.

Unlike a human partner, the autonomous Tickle will continue its tactile task reliably for a couple of hours—until its batteries need recharging. Tickle's lifelike behavior

Figure 2. Toy snake of hinged cylindrical sections.

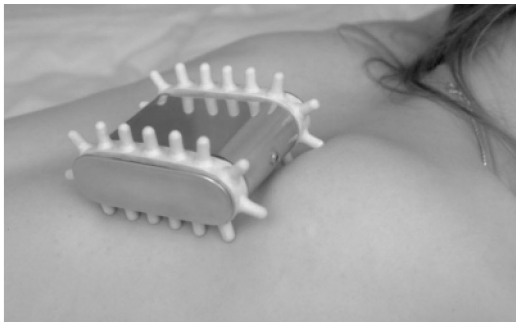

Figure 3. The autonomous Tickle. Photograph provided by the artists [16].

primarily relates to the way it interacts with its environment—the surface of a human, through touch and movement.

To make their point more clearly, the artists followed this device with another artificial life creation constructed to caress humans, Tickle Salon. The artists remark,

> The machine itself does not look like an organism the way Tickle does: it is attached [to the ceiling above a bed] instead of autonomously moving around. But its behavior is much more sophisticated and thoughtful [than Tickle's] as it learns over time. It has a 3-dimensional perception of space and can make complex movements through this space. It is truly a form of artificial life because it explores its surroundings, adapts and reacts to them in an intelligent and unforeseen manner. [16]

Tickle Salon has a soft feeler, which it uses to caress the human participant on the bed below, while it generates an internal model of the human's body plan through touch alone. The original Tickle was a purely reactive machine designed to wander around without falling off the human's body. The physicality of each of these works is a necessary criterion for their being able to interact with humans.

The Bonga, the cylindrical snake, and the Tickles are instructive for highlighting the role of physicality and interaction with the physical environment in our re-creations of life. As discussed above, each of the artifacts involves abstractions about living systems. The lifelike traits present in each are only a small subset of the characteristics we as artificial life researchers insist on. In some cases, the traits maintained are those that researchers may see as unimportant. Despite this, the shortcomings are easily overlooked, and our intellectual skepticism is contradicted by our gut responses to the devices.

The sense of animation in the above artifacts is strong. It is not mere wishful thinking on the part of their makers. This being the case, what features have artists and toymakers sought in software-based artificial life? Are they the same features that interest artificial life researchers working with software? In light of the examples above, it seems that the possibility for physical interaction is a major shortcoming of screen- and software-based artificial life. How has this been addressed by artists and toymakers?

3 Growth and Development in Software Toys

Bandai's Tamagotchi and its derivatives such as the Giga-Pets from Tiger Electronics were popular toys with children and also, especially in Japan, with adults. However, the fascination with the attention-seeking virtual pets of the mid-nineties seems to have

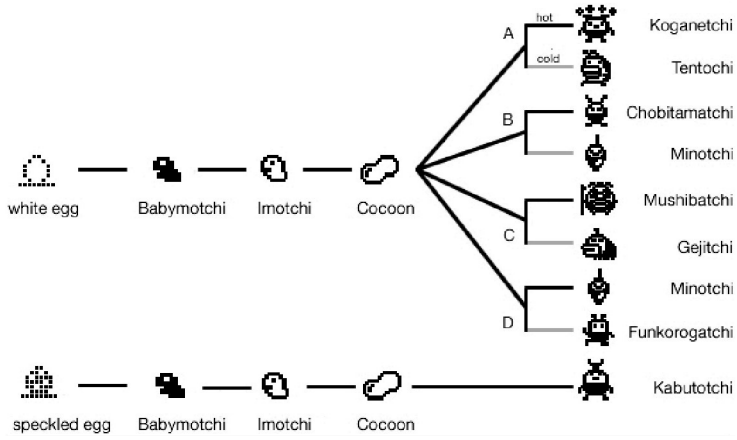

Figure 4. Mori-no Tamagotchi (Forest Tamagotchi) developmental chart (after [8]). The creature starts as an egg on the pixel display. If it is looked after by its human owner, it progresses to a cocoon. From there, depending on the "temperature" set by the human, the different types of cocoon develop into various mature adult creatures.

died out as quickly as it grew. A wide variety of Tamagotchi characters are available. They are all low-pixel-count forms, animated within the constraints of the wrist-watch electronics that encapsulates them. They "live" on an LCD display housed in a pocket-size plastic egg (tamago is Japanese for egg), which owners carry around on a key ring. As they interact with their human owners, these creatures develop along predetermined paths from virtual eggs to different adult varieties (Figure 4). What is the attraction of these devices?

One cannot sensibly discuss the success of the Tamagotchi without a remark about the Japanese obsession with *cuteness*, the native term for which is *kawaii*. Whether it be Hello-Kitty, Pingu, Doraemon, Pikachu, or any of the countless other characters from Japanese popular culture, *kawaii* has ruled the day for more than twenty years in Japan. Tamagotchi characters were a part of this national obsession.

It appears from a thorough scan of the countless Tamagotchi (and anti-Tamagotchi) websites, and even the artificial life literature [6], that the fascination with Tamagotchi comes in part from the dependency they have on their human. "It is dependent on you. That's one reason it became so popular," says Maita Aki, Tamagotchi's creator. "I think it's very important for humans to find joy caring for something." [9]

These simple arrays of pixels must be "fed," "bathed," and "entertained" in order to progress from newly hatched youngsters to full-fledged adults. The interactions with the outside world must occur through a simple push-button interface, and the complexity of the tasks required of the human keeper is trivial (e.g., select from an iconic menu to "feed" the creature, or engage in a simple repetitive computer game to "play" with it). The responsibilities of the human for their virtual pet are similar to those needed to keep a goldfish—the tank needs cleaning, the fish needs feeding, the lights need turning on and off at appropriate times.

The departure of the virtual pet's spirit (or, if you have the American version of the pet for thanatophobics, the departure of the pet from the game world) parallels the loss of a goldfish through neglect of its basic needs. If it weren't for this dependency, the Tamagotchi would have little to recommend it as a toy. Or would it? The graphics and animation are low-resolution, the audio is usually chirpy, and the mode of interaction is tedious. As far as the user is concerned, what is important is not what is, but what is perceived to be. As Baudelaire notes, when it comes to children and their toys,

"The soldiers can be corks, dominoes, draughtsmen, knuckle-bones, the fortifications may be planks, books, etc., the missiles marbles or anything else you like; there will be dead bodies, peace-treaties, hostages, prisoners, tributes to pay" [3]. In the case of the Tamagotchi, it doesn't really matter whether the virtual creatures look real. What matters most in this case is that they are *kawaii* and dependent on the human.

Some of the later model toys of the Tamagotchi type, such as Parex Electronics' Linkable Virtual Pets, incorporated mating and game play between the virtual pets. This was facilitated by a cable link between two of the toys. The cynics will say this was a clever marketing plan to encourage interactions amongst pet *owners*, who then needed to go out and buy the toys in order to be part of a social group.[1] All the same, various points of interest for this essay come into play. For example, the importance of sexual reproduction is being reinforced, the need for two creatures to reach maturity is replicated, and the relationship between the creatures must evolve through a number of stages: friends, lovers, and apparently a (shotgun?) wedding, after which time the female becomes pregnant. A virtual kitten arrives a few days later. The two characters may also, with some assistance from their owners, engage in a friendly game of digital tennis.

Equivalent linking pets targeted at young males included the Nano Fighter Pets. Nano Fighter Pet owners "train" their toys and, when they think their pets have sufficient strength, plug their toy into one or more daisy-chained units belonging to their friends. The attached units then do battle, and one is declared the winner. The others need nursing and regular care to recuperate. (This procedure parallels that applied to the BIO-Bugs discussed below.) The fights are not under human control; they are left to the creatures themselves. The human's role is only to prepare the pets for battle, as we have trained and bred pit-bull terriers, fighting cocks, and Siamese fighting fish in the past.

4 Interaction between Software and the Physical Environment

Of all of the electronic creatures contained in pocket-size boxes, one of the most innovative is Bitman from the Maywa Denki art group in Japan (Figure 5), producers of some exceedingly cute (certainly *kawaii*), bizarre, occasionally repulsive artificial life toy art pieces. Bitman is a human stick-figure that appears on an 8×8 pixel LED display, in an elegant, square, palm-size, one-button, one-dial white rubber-surfaced box.

Figure 5. Bitman at rest. From Ryota Kuwakubo / Maywa Denki art group.

1 This is borne out by the introduction, a year after the Tamagotchi craze, of the Lovegety [1]. These devices are about the size of a Tamagotchi. They do not contain virtual pets; instead they broadcast the presence of their male or female owner as well as his or her mood, to other owners of the same gadget within a radius of a few meters. If the toy owners like the real mates they have found, the couple can head off to sing karaoke or skip the formalities and "Get2" it.

The interface between Bitman and the outside world is an excellent piece of design. Simply tilt the box to one side or the other, up or down, or shake it vigorously, and Bitman responds. He may dance to different rhythms (played in quirky electronic tones from a small loudspeaker) and at different speeds, or he may jump up, down, and around his 8 × 8 grid world. If you hold the box upright in front of you, then rotate it clockwise or anticlockwise, Bitman walks around the edges of his world. He does this in such a way that he always stands, dances or jumps upright—he is subject to gravity. Quite a feat for an electronic character!

While the symbolism of the stick figure and the terrific animation (given the limited resolution of the device) persuade the human to identify Bitman as a "character," what is most appealing is his immediate response to the orientation of his container. This simple deception goes further towards making the character appear rooted in the physical world than many of the more complex attributes given symbolically to other digital pets.

Virtual pets built for roaming about on a computer desktop, the eSheep for example, may seem to be subject to gravity also. This can be confirmed in the case of an eSheep by iconizing a screen window from beneath its feet and watching as it plummets downscreen to the next horizontal window top or the bottom edge of the screen. However, the eSheep does not share Bitman's pseudo-physicality.

Bitman's symbolic representation enables him to appear to us to behave realistically and with fluidity. Since we interpret the symbols used to represent him transparently, without conscious effort, his limbs are not restricted to clunky movements governed by mechanical actuators and motors. Instead, his body configurations are interpreted as *fluid icons*, and the physical impossibility of his antics becomes irrelevant.

Additionally, Bitman encourages physical movements and activity in the human, something that desktop creatures essentially eliminate. Not only does this occur as discussed above, through shaking the Bitman housing by hand; the box is also intended to be accessorized with a necklace or a watchband. The active human owner may then wear Bitman on the street or to a night club as a fashion accessory, where he will respond to his owner's movements. Bitman worn in this way becomes a travel companion who responds to the physical conditions on the journey, something that the Tamagotchi is not designed to do.

While Tamagotchi are not built to respond automatically to their environment, the human tendency to anthropomorphize may overcome this limitation. For example, some years ago I bought a Giga-Pet kitten—Nano-Kitty—during a visit to the USA. I looked after it on my trip, and brought it home with me on the airplane. I had set the toy's clock when I was in the USA and I was now asking the toy, as I was asking myself, to adjust to the time differences between Australia and the USA.

Anyone who has made an international flight across time zones will realize the difficulty one's body has in adjusting to the change. In this instance, I tried forcing the Giga-Pet's body clock to do likewise—without success. It would wake up after I had turned its house lights out. It wanted to play when I was trying to sleep. It woke me with its incessant beeping to be fed at 4 am. The little kitten drove me crazy until finally I gave up tending to it and left it in my desk drawer. My pet got terribly ill and still I didn't care for it. Eventually Nano-Kitty packed up its belongings in a clean handkerchief tied to the end of a stick. It then wandered dejectedly off into the ether, leaving my pocket-size plastic egg-world desolate.

In this case, the toy's response to the changing time zone was (of course) enforced by my own attempts to adapt. Since the toy's refusal to adapt mimicked my own body's reluctance, it was easy to be sympathetic to its (lack of) response. I therefore considered the toy to be "jet-lagged," a description which of course is anthropomorphic, but, as is typical of such descriptions, is also quite satisfactory to the human as an explanation

for its behavior. Scattered about the WWW are other examples of children in particular, writing up their experiences with the Tamagotchi and explaining the behavior of their pets in similar ways. This raises the next question for this essay to address.

5 Giving Life and Taking it Away

The Tamagotchi craze raises the question: are there differences in the behavior of children when they interact with virtual and biological pets? Some have suggested we teach children that life and death are reversible processes by giving them virtual pets with on, off, and reset switches. They suggest that children learn that a pet's life may be temporarily suspended when its care is inconvenient or requires too much time and effort [15]. The opinion of one Tamagotchi hacker from the late nineties differs:

> I certainly don't think that mucking around with Tamagotchi is in any way a precursor to trying to reset the timers on your children. There is a real distinction that must be made, and all-too-often isn't, between real-life pets/children and computer games. Tamagotchi are nothing more than fairly simple computer games and should be treated as such. Most rational people will be quite happy to accept this discrepancy, and it's only media hype by the manufacturers and journalists looking for a shock-story that is drawing the virtual pet, (real) pet parallel. [14]

In this vein, an online petition caught my attention,

> A Sea-Monkey is a living pet, not a toy!
>
> To: All designers and manufacturers of Sea-Monkey products
>
> We, the undersigned ask all designers and manufacturers of Sea-Monkey products to bear in mind that Sea-Monkeys are actual living creatures and should be treated with the respect they deserve. We believe products such as pendants, pens, key-ring maze games and watches cause unnecessary suffering to these small crustaceans. The swimming space within these products is small, and they are, by their nature, designed for rapid movement, which can only result in injury. As they are watertight there is no way for air to enter the water.
>
> We also believe it is irresponsible of designers, manufacturers and distributors to sell kits to the general public which do not contain air pumps, which are critical for the survival of these pets or comprehensive instructions such as are found in the official Sea-Monkey Handbook. [12]

Sea monkeys are a species of brine shrimp, which may stay in suspended animation for many years. (The company that markets them for pets has tellingly registered the name *Instant Life*.) The marketing of these creatures as "toys" by some profiteers, without adequate measures being taken to provide for their well-being, has been problematic at least for some of the 1800 signatories who seem to be engaged in an amusing, often childish, sometimes heated and a little too serious battle with those who think the petition is a complete farce.

In contrast to the pleas of sea-monkey activists, an infamous norn torturer writes on his website:

> Many forms of torture cause physical injury of some kind. More injury means more damage to the norn, which shortens their lifespan. As *Norn Abuse* is fond of pointing out, death is a release for a tortured norn, and some people might not want that. Yes, it is fun to torture a norn to death, but it can also be fun to see how long you can keep a norn alive under abusive conditions. The *RedCross cob* automatically injects all norns in range with organ healing compounds (prostaglandin and vitamins), and antibodies for all known antigens (if you are torturing a norn, you don't want to have to waste time nurturing it back to health from an illness, do you?). Place one of these in your norn's cage, make sure the creature gets plenty of food and rest, and you shouldn't have to worry about its health. [2]

The norns, created by the now defunct company Cyberlife/CreatureLife, are PC-based virtual pets drawn with wide eyes and droopy ears. Anti-Norn, the owner of the norn torture website, has apparently received a substantial amount of abusive hate mail, even death threats for the experimental "torturing" of his virtual pets. For a while the topic was hot on Internet newsgroups and in chat rooms; it even made it into the occasional computer section of the mainstream press [4].

Is this interaction significantly different from that of the video game player who machine-guns, karate-kicks, eats, or knife-slices his opponents? It seems the "torturer" struck a raw nerve with his actions. Somehow these must differ in the mind of the game-playing community from those usually associated with a video game—or perhaps I'll soon locate a "Save the ghosts from Pacman" petition.

The issues concerning virtual torture become somewhat more murky when the life of virtual characters cost players time, energy, and/or real money to develop and maintain. When a parent spends $1000 on eBay buying a "powerful" but nevertheless *virtual* character for their spoiled child to use on *Everquest*, a popular Sony role-playing game, the parent attributes a concrete value to the virtual life form. This value exists independently of moral and ethical concerns about the value of the virtual character's "life," but is related to the amount of real energy a player must invest in establishing a character of that caliber in the game world.

If the child's character is "killed," "tortured," or "slaughtered" by the characters controlled by other players, the pattern of data that represents it has been altered in a significant manner. That is, the data has been changed from a state where the player may use it to interact with other characters in the game world, to one which is no longer responsive in this way. This amounts to destruction of property, albeit in an environment where that is an expected outcome of participation. The fact that his character's "life" has been taken may also have a significant effect on its guardian.[2]

In the physical world, the destruction of a symbol can have a powerful effect that far exceeds in importance the destruction of the material from which it is made. For example, a burning effigy or a flag trodden in the mud will certainly anger people, or incite them to real violence. It is therefore not at all surprising that the "torture" of norns or the wanton destruction of avatars and virtual characters is considered unacceptable behavior under some circumstances. It may well turn out to be irrelevant if virtual life is exactly equivalent to real life. If people will campaign with vigor to save the sea monkeys and save the norns, it looks as though our moral and ethical standards are coming into play for virtual life as well as simple forms of real life, regardless of the other distinctions we may wish to make between them.

2 There is a documented legal case involving a child suicide that the parent believes was caused by an event in the Everquest game world. In addition, there have been cases between Sony/Verant and game players who have tried to profit from their time spent playing Everquest by selling virtual characters and game artifacts on eBay. I bring these cases to the reader's attention lest I be taken to task for inventing hypothetical situations which are seen as ridiculous.

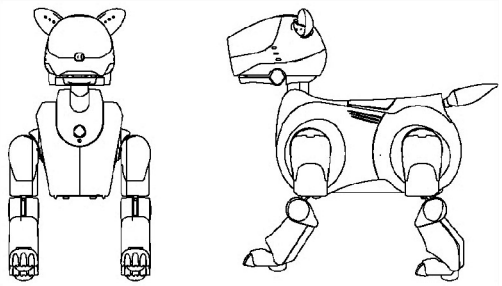

Figure 6. Aibo schematic [13].

6 Robot Pets, Soccer Players, and Gladiators

Kusahara explains that in Japan, the best-known commercially available robot pet, Sony's Aibo (Figure 6), is treated in all seriousness as a legitimate artificial companion [6]. Personal communication with Japanese friends has tended to support this claim, despite its apparent outlandishness to Western ears. Perhaps further surprising to a Westerner, the level of acceptance seems especially high for *elderly* people. The Aibo robots are sophisticated imitation dogs and cats and consequently fall outside the price range of the majority of children (and this author). Although externally the robots (and their less sophisticated cousins, such as SilverLit electronics' iCybie) resemble their flesh-and-bone brethren, it is not clear to what extent the internal workings are based on artificial life principles most researchers in the field would recognize as their own.

One thing to note about Aibo in light of the discussions in Section 2: The robots are covered with plastic, not artificial fur. Although the makers of other toys, such as Axlon's Petsters of the mid-eighties, resorted to furring their pets, the Sony devices are so sophisticated in their behavior that even their hi-tech robot shell does not obscure (nor detract from) the sense of animation they convey. Perhaps the high degree of acceptance of digital technology in Japan also has much to do with the Sony designers' decisions.

The Aibo Open-R (Aibo application programmer's interface) bulletin board for developers is filled with banter about wireless networks, bandwidth, computer vision, joint angle controllers, and so forth, but little of relevance to those of us interested in self-organization, self-assembly, or even mimicry of real living systems. As with the toys above, it seems that although the appearance and behavior of animals are important considerations in the design of the toy, at this stage in our technological development we depend on traditional engineering paradigms to build devices that mimic life as we wish.

Despite the paradigms upon which their architecture is based, teams of Aibo have been programmed to play against one another in the international RoboCup soccer tournaments. Arguably this is an endeavor that aims to imitate the team behavior of (human) living systems as well as the ball-handling skills of individuals. Experimentation of this kind relates closely to artificial life research interests in self-organization and group behavior. The RoboCup website states its goal: "By the year 2050, develop a team of fully autonomous humanoid robots that can win against the human world soccer champion team" [10]. There are shades here of Vaucanson's mechanical musicians. While Aibo is involved in the current competitions, the organizers of these events hope that eventually humanoid creations will surpass us at sport, as Vaucanson hoped of his own androids in the musical arena.

In the case of RobotWars [11], the destruction of battle-designed machinery thrills viewers who are confronted with human fragility in the face of their own merciless

artifacts. This thrill seems similar to that aroused while watching a gladiator fight a lion or a bullfighter a bull.

There is no doubt that machines can be stronger and faster than humans. The interest therefore lies in the ability of humans to conceive machines with intelligence and coordination to match our own, not in the ability of steel to surpass bone or gears to surpass muscles. Hence the requirement above that the robot soccer team must beat us on our own terms is an interesting one.

The rules of soccer are set by humans; the robot limbs must mimic human limbs. The interest to engineers lies in the difficulty of the problem domain—it is far from a trivial task to set in motion an android that can play within the strict constraints laid down by the RoboCup organization. For the same reasons, it is somewhat less interesting to contemplate the outcome of placing a human in an environment suited to robots (or into an arena suited to lions for that matter) without allowing recourse to the unique traits we possess that enable us to level the playing field.

In contrast to Sony's marketing links between Aibo and artificial intelligence, Hasbro takes an approach to marketing that borrows instead from biology and artificial life. Their toy Biomechanical Integrated Organisms (BIO-Bugs for short) are designed to facilitate hacking, reconstruction, and modification, so that owners will further the "evolution" of their robots beyond the capability of organic beetles. Such ideas are also reminiscent of those behind the popular Lego Mindstorms, marketed with the catch-cry "Create robots you can bring to life and control."

To return briefly to the essay by Baudelaire mentioned above, he notes, "The overriding desire of most children is to get at and see the soul of their toys, some at the end of a certain period of use, others *straightaway*.... The child twists and turns his toy, scratches it, bumps it against walls, throws it on the ground. From time to time he makes it restart its mechanical motions, sometimes in the opposite direction. Its marvelous life comes to a stop... at last he opens it up, he is stronger. *But where is the soul?*" (Baudelaire's emphasis) [3]. It is apparent that in Baudelaire's time, as now, people have enjoyed opening and modifying complex machines. By manufacturing Aibo, the BIO-Bug, and Lego Mindstorms in such a way as to promote hacking, Sony, Hasbro, and Lego are appealing to the engineer in the male target demographic. The toys then become subject to experiments conducted by backyard roboticists, who rebuild them within their abilities, or destroy them completely.

Out of the box, BIO-Bugs can apparently learn to communicate and propel themselves around a space. They may be trained by human users as well as through interactions with the environment and each other. These capabilities are facilitated by touch-activated sensors and mechanical effectors as well as by infrared emitters and sensors. The creatures may also emit audible squeaks and bleeps for communication with humans. The extent to which the advertising material for these robots reflects the reality is not known to this author. What is clear is that despite the many avenues that could be explored with these robots, their marketing campaign focused on their ability to fight. As with the Nano-Fighting Pets, RobotWars, the EverQuest characters, and the tortured norns, the themes of giving and taking life and of diverting it to our own ends are ever present. The thought of Frankenstein's monster living a life of its own beyond the control of its creator, the idea of artificial life set free, remains as frightening to us now as in the past.

7 Conclusion

In the limited space available a survey of mechanical, electronic, and composite toys of various types has been made, largely according to the whim of the author. No doubt every reader has in mind another toy that might also have been discussed in this article.

The traits toys seemingly exhibit that allow us to identify them as lifelike vary from device to device. They include mimicry, simulation (or in some cases instantiation) of various aspects of living systems, among them the ability to breathe, write, think, play music, reproduce, fight, crawl, eat, respond to their environment, grow, die, dance, demand attention, and a host of others. What remains open is the degree to which each of these traits is purely metaphoric.

Even if all of these behaviors are only metaphorically possessed by the toys, we have shown the extent to which our response to biological organisms is determined by our intuition, since it is to this that toymakers have applied their deceptions. Although our perceptions of animation in artifacts frequently contradict our intellectual understanding of biology, we are easily led astray. Is this a bad thing? Toymakers and some artists depend on this characteristic for their success. Furthermore, if designers can create machines that are intuitive to use, they also consider themselves successful. Hence, an understanding of the way we interact with living things may be of benefit, not only to toymakers and artists, but to industrial designers as well.

Perhaps in the future we may have garden sprinklers that we "frighten" out of the way as we travel to the back shed, mobile cameras on legs that record family events based on their own "interest," or scarecrows that actively chase birds from the fields. Surely there are many devices which would benefit from a dose of lifelikeness in keeping with our current level of technological innovation? Perhaps instead, a real test of our engineering skill is to match our own sense of intuition with that of a machine, rather than to reconstruct the planned and logical thought we claim to be our most valuable asset.

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