Dead Technology

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Sony's robot dog, Aibo, playing dead

For thousands of years, technology has been breaking.

- ***Psalms 31:12***

  I am forgotten as a dead man out of mind: I am like a broken vessel.

- ***Othello I:3***

  Duke of Venice: Men do their broken weapons rather use / Than their bare hands.

- ***The Blues Brothers*** **[Landis, 1980]**

  Corrections Officer (returning the possessions of Jake Blues on his release from Joliet Prison): One Timex digital watch - broken. One unused prophylactic. One soiled.

For thousands of years, people have been dying.

- ***1 Corinthians 15:22***

  For as in Adam all die, even so in Christ shall all be made alive.

- ***Henry VI Part i, III:2***

  Lord Talbot: But kings and mightiest potentates must die / For that's the end of human misery.

- ***Buffy the Vampire Slayer*** **[1997-99]**

  Buffy: The world is what it is---we fight, we die. Wishing doesn't change that.

Only recently, though, has technology begun to die.

- ***Ferris Bueller's Day Off*** **[Hughes, 1986]**

  Ferris (after his friend crashes his father's Ferrari) You killed the car.

- ***Small Soldiers*** **[Dante, 1998]**

  Chip Hazard (eulogizing a dead toy soldier) His battery is dead but his memory lives on.

- **"Requiem for a Macintosh"**

  Tom McNichol
  New York Times Service, Saturday, March 7, 1998
  (http://globetechnology.com/gam/News/19980307/TADEAD.html**)**

  My computer died last week.

  If you think it's strange to talk about a computer dying, as if it were a living thing, that's probably because your computer is still alive. Mine's dead. Passed away. The Final Sign Off. Dragged to the Big Trash Can.

How can technology die? What is there about modern machines that causes them to deserve words usually reserved for living things? Do machines really *die*, or are we just saying that?

Common sense makes some clear distinctions in the areas of life and death. Something is either alive or it is not-alive. Among those things that are not-alive, any that used to be alive are called "dead". English has no clear word for the state of being neither alive nor dead ("inanimate" is about as close as it gets).

The role of machines in people's lives has evolved during this century. In 1921, Karel Capek coined the word "robot", derived from the Czech word for hard, menial labor, in his play *R.U.R.: Rossum's Universal Robots*. [Kapek, 1921] In the 1950's, supercomputers were treated with the utmost of respect by their white-lab-coated priesthood. These days, computers are commonplace, and often take the place of companions, as people sink vast quantities of time into computer games and the internet.

The words and metaphors that we use in referring to these machines reflect this shifting emphasis from menial labor to social acquaintance. When a laboring machine stops serving its purpose, it is broken. When a companion stops serving its purpose, it has died. Everybody knows that machines aren't alive. Nevertheless, modern machines interact with us on our own terms, by means of appropriate input and output devices and internal models of the world that resemble our own. Although they aren't alive, machines are now being endowed with the characteristics of living things, in order to make them work more effectively in the service human societies. As they become more familiar, machines are growing into the words that are reserved for people, pets, and other living things - "grumpy", "tired", "alive", "dead".

As a graduate student working with Professor Bruce Blumberg in Synthetic Characters Group at the MIT Media Lab, (`http://characters.www.media.mit.edu/groups/characters/`) I help design machines that resemble living things. By machines, I mean a wide range of technological products, from real objects to entire virtual worlds. Using the study of animal behavior as our model, we make autonomous virtual creatures who are able to sense things in their virtual world and combine these sensations with drives, motivations and emotions in order to choose which actions to take at each moment. [Blumberg, 1996] [Kline, 1999] An understanding of human perceptions of life and death can help us to design machines that more effectively mimic life.

Humans have a variety of mental triggers that help us recognize living things. For survival reasons, it is important for us to be able to recognize quickly that something is alive; living things are dangerous or edible or sexy. By accepting an object as "dead", a person inherently acknowledges that it was once alive. By exploiting a variety of these triggers, designers of technology can profoundly alter people's perceptions of machines.

These triggers work because of the principle of abstraction. Our minds create constructs to help us categorize the things we encounter - to pigeon-hole everything with easily-comprehended labels. These mental abstractions often have words attached to them. "Red", "Big", "Alive", "Dead". Each has a definition that represents the internal mental picture that each of us maintains. Abstractions do not deal with gray areas. In order to talk about the border conditions, people use the "-ish" suffix, the "sort of" and "somewhat" prefixes, and other mitigators.

One of the triggers that correlates most closely to an object being perceived as alive is the possibility of it dying. All living things die, eventually. Everybody knows that. (Whether or not it's actually *true* is irrelevant. What matters is that it is "common knowledge".)

In the process of creating systems that fit loosely into the field known as "artificial life", I've come across many examples of living things, subsets of living things (e.g. artificial skin) and systems that imitate living things. I have found there to be a gradient between things that we consider to be alive and those that we do not. Humans are alive. Sledge hammers are not. But how about frozen fertilized human eggs? How about brain-dead bodies on artificial respirators? How about a "living" dog's nervous system suspended in saline solution? Or the rest of the dog, with digital relays where the nerves used to be? Some of these things may not exist yet, but they will soon. Technology is exploring the gray area that separates the black and white of living and non-living.

When many triggers fire for recognizing something as alive, but others fire pointing to some other category, a cognitive dissonance occurs. This results in a psychological phenomenon that stems from the human tendency to recognize abstractions by means of triggers - the abomination. Mary Shelley's "Frankenstein", first published in 1818, is the archetypical symbol of technology run amok - it seems alive, and yet is a human construct. It has filled readers with dread for more than a century and a half. In making living machines, designers must learn how not to create beings that are close to being alive, but miss the mark.

I am interested in contributing to the creation of new forms of life by means of technology. This begs a few questions. Can machines ever be truly alive? Why do we want to create things that are alive? Why is it better for these things to be acknowledged as alive than not-alive? Do we somehow benefit from their death? Or would we just get jealous if machines were as smart as us and did not die?

LIFE-LIKE

There exists a service, called MovieFone, by which I often find out about movie screenings. By dialing 333-FILM, I contact Mr. MovieFone, and we chat:

> **Mr. MovieFone:** Hello and welcome to MovieFone! If you know the name of the movie you'd like to see, press one now!
>
> **Me:** BEEP
>
> **Mr. MovieFone:** Please enter the first three letters of the movie title now!
>
> **Me:** BEEP BEEP BEEP
>
> **Mr. MovieFone:** You have selected *Star Wars: The Phantom Menace*!
>
> etc...

Young Annakin Skywalker, a boy in *Star Wars: The Phantom Menace* [Lucas, 1999], says to R2D2, a droid, "Take us off autopilot, R2, or we'll both be killed." The boy thinks the droid can be killed, just like him. R2D2 emits several beeps to show his agreement.

When R2D2 talks to people, the little droid beeps. When people talk to Mr. MovieFone, the people beep.

There is a use for machines that are life-like. People are exceedingly skilled at dealing with other people and with animals. With regard to other life-forms, we are expert users. Making machines that are more like the beings that we are accustomed to interacting with will make it easier for us to deal with those machines.

By asking us a series of questions, Mr. MovieFone plays on an oral tradition that goes back as far as Socrates. Rather than arriving at some point of philosophy, we determine what tickets I want to buy. Useful, if not profound.

Spoken language is ubiquitous in human cultures. By making machines that can communicate with us in our own language, technologists are reducing the amount of new information we need to acquire in order to successfully employ their technology. People are less and less willing to give a substantial amount of effort to learning a task in the information age, when time is so valuable, and software companies change interface designs with distressing frequency.

The manipulation and training of audiences is nothing new. The good people at Disney are quite talented at capturing the simplistic essence of characters on film. The book *The Illusion of Life* [Thomas and Johnson, 1981] offers up many of their tricks-of-the-trade for conveying personality with moving pictures. By

exaggerating motion and caricaturing features, drawn animation emphasizes the elements that make different characters unique.

The exaggerated action that Disney so often uses is, in essence, a supernormal stimulus for our tendency to recognize living individuals. Supernormal stimuli abound in the natural world. Cowbirds lay eggs in the nests of other birds; their chicks exhibit characteristics (large size, noisy calling, energetic motion) that make it more likely for the host bird to feed the cowbird chick than its own chicks. [Alcock, 1989] By exploiting the same process - endowing objects with characteristics that are supernormally life-like - technologists can manipulate audiences into perceiving life in their products.

In the world of programming, Java has been the hot new language for a few years. Its essential premise is known as object-oriented programming. This allows programmers to design and write software using the same conceptual framework that people use when analyzing the world around us. Pieces of code can be understood as black boxes that take certain inputs and provide certain outputs, rather than as a complicated series of function calls. By considering all digital concepts to be objects, Java makes it easier for programmers to understand complex structures.

Commercial software packages are beginning to be made more life-like as well. One of the most well-known examples in the digital arena is the Microsoft Word Paperclip. The Paperclip is a digital character in the shape of a little paperclip, who appears on your screen whenever you press the button for help. Microsoft Word is quite complex, so Microsoft wrote a very effective help program. The help technology underlying the Paperclip generally offers the right answer with a minimum of difficulty. Microsoft added to this help technology a character who winks and ogles at you as it helps you use Word. The Paperclip has received mixed reviews, with some people enjoying the antics of the Paperclip, and others finding it to detract from the effectiveness of the help program.

Microsoft Word Paperclip

When employed with discretion, the use of characteristics of living things can do wonders for enhancing inanimate objects. Machines that tactfully mimic people and animals in order to ease our interactions with them are the way of the future. In order for our creations to mimic living things, technologists need to understand just what the qualities are that make us see something as alive.

TRIGGERS

> "Why do you cry, Gloria? Robbie was only a machine, just a nasty old machine. He wasn't alive at all."
>
> "He was *not* no machine!" screamed Gloria fiercely and ungrammatically. "He was a *person* like you and me and he was my *friend*. I want him back. Oh, Mama, I want him back."
>
> [Asimov, 1950]

There are many triggers that cause people to recognize something as alive. This section will be a list of a few of them, and examples from the variety of human products that employ them.

Quality of Motion

Living things have very distinctive motion styles. Whereas servos and metal move in exact, rigid and constant ways, animals move along fluid, smooth, continuous paths. Natural-looking motions tend to minimize jerk – they move in such a way that there is a minimum of energy expended for each motion. In the real world, many motion characteristics are taken for granted – for example, it is not possible to have a position discontinuity. Nothing ever moves instantaneously to another position. In the world of graphics, though, it is quite possible for an image to appear suddenly in a new position. Animators spend a great deal of their time creating smooth, continuous motions, which lack unnatural motion characteristics. Every

animated film and video game features the work of an army of animators striving to give a natural look to the motion of their characters

Reaction to Stimuli

Video games appeal to a very strong model in our brains, that living things react to stimuli that they perceive in the world. In *Pac-Man*, the ghosts chase the Pac-Man. They sense his presence, and pursue him. Games are full of creatures, some simple, others quite complex, who react to the actions taken by the human player.

Physical Presence

Aibo, the robotic dog produced by Sony, (`http://www.world.sony.com/robot/index.html`) has many characteristics that make it seem alive. Perhaps the greatest of them is its sheer physical presence. Having a physical embodiment, rather than a purely digital presence, is quite compelling in a creation of technology. Aibo looks like a dog.

Plausible Unpredictability

Animals are complex, and therefore take actions that are frequently unpredictable. A rock dropped from a height will accelerate at 9.8 meters per second squared toward the ground. A butterfly, when dropped, will certainly not. It is as liable to go in one direction as another.

One of the simplest toys is a hollow bean with a little round weight in it. This toy, often sold as a Mexican Jumping Bean, has quite unpredictable action when rolled. This unpredictability is easily interpreted as complexity, since our mental models are on the look-out for complex behavior from living things.

Adaptability

Mr. MovieFone changes his questions based on the caller's answers to previous questions. While he operates in an exceedingly constrained domain (he can't sell opera tickets or offer psychological counseling), he asks the appropriate questions to narrow down exactly what movie tickets the caller wants to buy. Living things have the ability to adapt to changing circumstances on a much greater scale than Mr. MovieFone.

Nutrition and Growth

Tamagotchis (`http://www.bandai.com`) are little toys in the shape of an egg about two inches long. They have several buttons, which allow the owner to take a variety of actions on a virtual creature that inhabits the egg. Owners can feed, play with, clean up after, and train their creatures, who need attention every few minutes over a period of days or weeks. Since there is no way to turn them off, and they beep when they are hungry, they are rather insistent in their demands for attention.

Tamagotchis appeal to the nurturing instincts of children. They require nutrition, in the form of button clicks, in order to grow. Tamagotchis are an excellent example of behavioral, rather than anatomical, triggers - they look like little eggs with exceedingly low-resolution displays, but they provoke very strong reactions in their owners. That is because they mimic living things effectively, simplifying the elements of life into easily recognizable versions of eating, learning, playing, excreting, growing and dying.

Tamagotchi

Fuzziness

Most stuffed animals are fuzzy. Mammals all have hair of one kind or another, so fuzziness has a strong correlation to mammalian life. This is an example of a trigger that is not simply correlated to life, but to a specific kind of life, one that is closely related to humans.

Irreversibility

Furby (`http://www.tigertoys.com`), a toy the size of a small stuffed animal, exploits many of the same triggers that are used by the tamagotchi. The creatures learn from their environments in a continuous fashion. This is one of the great features of this new breed of toy - furbys, tamagotchis, and the computer programs Dogz and Catz (virtual pets who live on the desktop of a personal computer) - they all change and develop in real time, with an irreversibility that has traditionally been exclusive to animals. These new toys have no undo function and they cannot be fixed once they die (though some have ways that they can be restarted). Most computers can be restarted once they crash. There is something peculiar to living things that they can not be brought back to life. There is a level of accountability to the owner/user of a machine that can not be reset; any actions become part of the permanent state of that machine. This is much closer to a human-human interaction, where people remember what you've done before, than to a machine that doesn't hold a grudge.

Furby

Self-Interest

For a project entitled "Swamped!" that we presented at SIGGRAPH '98, the Synthetic Characters Group created a virtual raccoon who had a system of behaviors that incorporated drives (e.g. hunger), emotions (e.g. anger) and sensors (e.g. smell) in its decision-making process. The raccoon looks around its world for chicken eggs, and then, if it is hungry, tries to eat them. He's pitted against a chicken who is trying to protect her eggs.

The raccoon has many of the signs of life. He tries to find food, and explores the world as a real raccoon might. By basing the raccoon on the study of ethology, which analyzes animal behavior, we built a creature who pursues his own self-interest in a virtual world.

The Synthetic Characters' Raccoon from "Swamped!"

Bodily Fluids

In the movie *Predator* [McTiernan, 1987], Arnold Schwartzenegger offers another trigger – "If it bleeds, we can kill it." While there are not too many toys these days that bleed, it is a strong trigger for animal life. Other bodily fluids are sometimes used, in baby dolls that cry or urinate, and pro-wrestler dolls that sweat.

Death

Perhaps the greatest trigger for life is death. All living things die. Dead is a special sub-set of not-alive, in which the item in question used to be alive. If people are willing to grant that something is dead, it must at some point have been alive.

Doom, the "first-person shooter" computer game, in which the player controls a character who uses an assortment of big guns to wipe out squadrons of bad guys, is the archetypical example of death bringing a scene to life. John Romero, the co-creator of *Doom*, was recently interviewed about the development process. They had made a similar game, called *Castle Wolfenstein 3D*.

> But something wasn't quite right about [*Castle Wolfenstein 3D*]. "Everybody thought it was awesome," Romero recalls. "But when we started playing, it was like, 'We have to have more blood, more violence in there.' It seemed real, but we needed to show the guys dying."
>
> [Keegan, 1999]

This led to *Doom*, where gore flies freely.

Death is the ultimate trigger for life. Death lets you see the insides of a creature, find out what it's made of, hear the noises it makes *when it really matters*. When you blow away an adversary in *Doom*, the blood is bright crimson, and there's always enough of it.

Taxes

Crotchety old men sometimes say "Only two things in life are certain - death and taxes." Death is an unavoidable part of life. There are lots of examples of virtual creatures that employ death as a way of making themselves seem alive. Perhaps someone should invent a toy that just whines about having to pay taxes.

Technologists are actively creating machines with the traits of living things. My group builds synthetic creatures on the model of animal behavior. Roboticists build machines that sense and respond to their environment. By considering dichotomies like "dying" vs. "breaking", we may be able to create beings that more effectively trigger the stimuli in human brains that cause us to decide whether or not a thing is alive.

ABSTRACTION

All knowledge forms one whole, because its subject matter is one; for the universe in its length and breadth is so intimately knit together, that we cannot separate off portion from portion, operation from operation, except by a mental abstraction.

John Henry Cardinal Newman
The Idea of a University: Defined and Illustrated (1941)

One of the most important concepts in computer science is abstraction. In order to design computer programs that are modular and efficient, it is valuable to isolate the qualities that several things have in common, so that they can be dealt with in the same manner with respect to those qualities. It makes programming faster, too, since it isn't necessary to duplicate common lines of code.

The workings of an animal brain benefit from an ability to abstract, as well. In order for an animal to be able to deal with the myriad of objects and organisms in its every day life, it needs to be able to abstract away common elements and thereby comprehend the differences. The difference between a tiger and a lion is much less pressing than their common status as big-cats-that-can-eat-me. It is far more important to decide rapidly that an animal is a threat than to assess whether or not it's a striped threat.

The great advantages of abstraction - rapid response time, lower memory requirements, ease of programming - make necessary a certain drawback - the lack of absolute precision. A tiger that leaps at a person in a zoo still triggers that person's flinch response, even though the person knows that metal bars will stop the tiger before it sinks its teeth into his neck. The evolutionary survival benefit of this kind of reflex greatly outweighs the relatively small energy cost of flinching, even when it is unnecessary.

Since it would take too long to comprehend fully every element of every object in the world, animals develop tactics for effective rapid categorization. Certain elements provoke a very strong response. For example, people seem to be very good at recognizing faces. Eyes, noses and mouths seem to pop out of everywhere - clouds, parking meters, houses. Certain patterns and arrangements in our perception of the world trigger striking responses.

We have triggers for many things. Colors, textures, sounds, tastes and smells can all cause strong associations with other things that they remind us of. While these triggers may not be 100% accurate, they have proven to be accurate *enough* to keep us and our ancestors alive. The small differences are not nearly as critical as the rapidity and efficiency of categorization.

In dealing with objects in the world, it is valuable to be able to distinguish between things that are alive and things that are not. Living things take action, move quickly and need dealing with right now. Most non-

living things will still be there tomorrow. Therefore, animals have developed a strong understanding for the difference between living and non-living things. These are two very strong abstractions.

Another firmly entrenched dichotomy is that of alive and dead. Most people try to steer clear of the uncomfortable middle ground. In a discussion of the old adage that rattlesnakes don't die until after sundown, Gordon Grice writes:

> We ordinary people (that is, not medical professionals) generally believe in the principle of brain death. Brain death as a concept frees us from the responsibility of deciding death, because it is a completely invisible distinction. No layman has the equipment to measure brain activity. With the means of officiating out of our hands, we don't have to decide; we bring our dying to the hospital, a kind of temple, where doctors, in their roles as secular priests, make the pronouncement. They use technology incomprehensible to most of us to make the call, and then they declare a time of death on official documents - as if death happened in an instant.
>
> [Grice, 1999]

Our lives are full of ways that we avoid confronting anything that doesn't fit into our precise categories. Hospitals and institutions hold our borderline cases. Disney films are chock-full of characters that are good *or* bad, whereas all real people are good *and* bad. Laws are designed to do away with ambiguity - jurors are instructed to decide cases based on whether the facts fit a proscribed definition of a crime. Even so, everybody avoids jury duty.

THE GRADIENT

Definitions of Life:

> **Webster's Dictionary: (**`http://www.m-w.com`**)**
> **1 a :** the quality that distinguishes a vital and functional being from a dead body **b :** a principle or force that is considered to underlie the distinctive quality of animate beings -- compare VITALISM 1 **c :** an organismic state characterized by capacity for metabolism, growth, reaction to stimuli, and reproduction
> **2 a :** the sequence of physical and mental experiences that make up the existence of an individual
> **...**
> **12 :** the period of duration, usefulness, or popularity of something <the expected *life* of flashlight batteries>
> **...**
> **14 :** a property (as resilience or elasticity) of an inanimate substance or object resembling the animate quality of a living being
> **...**
> **17 :** one providing interest and vigor <*life* of the party>
> **...**
> **20 :** something resembling animate life <a grant saved the project's *life*>
>
> **NASA: (**`http://afc.gsfc.nasa.gov/tco/biology101_01.htm`**)**
> All life carry on a common set of processes:
> Reproduction - the production of new individuals of each kind of organism
> Growth - life grows in size
> Nutrition - activities involved in taking in food from the environment, digesting the food and removal of wastes of digestion.
> Transport - the movement of material into the life form (cell) and the distribution of material within the cell.
> Respiration - chemical activities that release energy from organic molecules for the use of the organism.
> Excretion - the elimination of waste products from the organism.
> Synthesis - chemical reactions in which molecules combine.

Regulation - the control and coordination of all functions (no wonder we are such natural bureaucrats it is built into the meaning of life)

Christian Science: (`http://www.tfccs.com/GV/harvard/vhtalk.html`**)**
The Bible's message assures us that God is Life.
Virginia S. Harris, Chairman of The Christian Science Board of Directors

Proverbs 12:27-28 (`http://etext.virginia.edu/kjv.browse.html`**)**
The slothful man roasteth not that which he took in hunting: but the substance of a diligent man is precious. / In the way of righteousness is life; and in the pathway thereof there is no death.

Buddhism: (`http://spiritonline.com/buddhism/index.html`**)**
Life is Suffering.

There is some debate over just what life is. Various groups propose this or that exact definition. I propose that there is a gradient between alive and not-alive. This is why no one can agree - there is no exact dividing line. Rather than disagreeing about *truth*, people are haggling over boundaries.

Usually, people never have to deal with the gradient, because the two extremes suffice in the vast majority of judgements. We know which things in our daily life are alive - people, dogs, mosquitoes, trees, grass. We know which are not alive - rocks, books, clothes, rubber-bands, desks. We know which things are dead - our lunch, our ancestors, our leather shoes. We rarely encounter the things that push our definitions - people on life-support, embryos, artificially-grown skin. When we do, we even more rarely need to decide whether it is alive, dead, or neither of the two.

Technology is complicating matters by creating more examples on the border between the three cases. How much of a person needs to exist in an artificially-supported apparatus before it is considered alive? A cell? A liver? A heart? A brain? An entire nervous system? A nervous system with ears? A nervous system with ears and a mouth? If it can hear you and talk to you, I'd bet you'd consider it alive.

Not so with machines. Mr. MovieFone can hear people and talk to people, and has a simple machine brain that chooses outputs based on its inputs. But no one ever thinks Mr. MovieFone is alive.

In her essay "A Cyborg Manifesto", Donna Haraway considers the "leaky distinction" between organisms and machines.

> Late twentieth-century machines have made thoroughly ambiguous the difference between natural and artificial, mind and body, self-developing and externally designed, and many other distinctions that used to apply to organisms and machines. Our machines are disturbingly lively, and we ourselves frighteningly inert.
>
> [Haraway, 1991]

Even if you have a consistent definition of life for all things that currently exist, there are some curve-balls currently in the works for you. The field of biological computing is going to complicate matters. (`http://www.lcs.mit.edu/research/projects/project?name=9922`) This field focuses on encoding information on DNA, rather than in silicon. Are these "computers" alive or not?

How about the Tissue Culture & Art project (`http://www.imago.com.au/tca/`), which is growing live rabbit cells over glass sculptures? Their goal is "To explore the use of tissue engineering to develop semi-living entities." Ultimately, this could result in living furniture - couches made out of live cow flesh instead of leather. Projects like these make it hard to nail down an exact definition of life.

Our reticence to address the gradient between living and non-living does not mean that it does not exist. In fact, the existence of a gradient enables an interesting phenomenon to occur - hill-climbing. Gradients by definition have a gradual slope, rather than a discrete cut-off. This slope means that an evolving type of

entity can proceed from one side of the slope to the other by means of arbitrarily small intermediate steps, rather than in one giant leap. Just as a person climbing a hill takes small steps and eventually reaches the top, a not-alive type of entity may gradually become more complex and take on the requisite characteristics of a living thing. By blurring the boundary between living and not-living things, technology is making possible a pathway for gradual ascension to life.

Just as there is a gradient from non-living to living, there is a gradient from living to dead. Dead things were once alive, but now are not-alive. "We would like to think death is a crisp fracture: living, and then not living. In fact, there is no clear division between life and death in any animal. People sit up, fart, and twitch long after they are apparently dead, and an arcane lore of medical and legal specifications has grown up to deal with the practical difficulties of this sloppy division." [Grice, 98]

So if there is a gradient between life and death, why do people cling to the artificially precise dichotomy between the two? Because it is the most efficient way to think about things. It's not biologically economical to spend much time thinking about things that we rarely come across in daily life. "Forgive him, for he believes that the customs of his tribe are the laws of nature!" - George Bernard Shaw, *Caesar and Cleopatra*

ABOMINATIONS

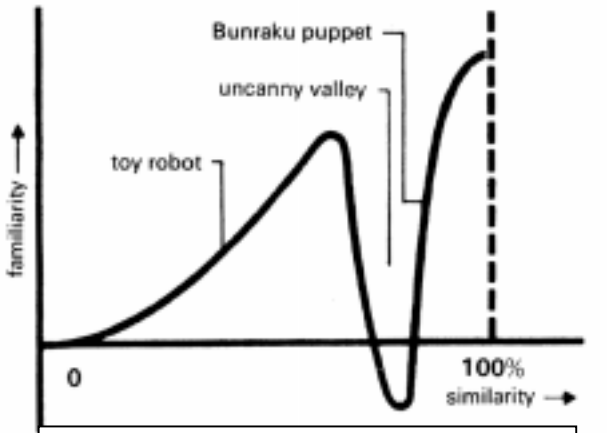
A dog with its head ripped off is dead.

A stuffed animal with its head ripped off is broken.

A stuffed animal with its head ripped off, lying in a pool of blood, is dead.

There is a problem with the creation of machines that are like life. It is the abomination. When an object is very life-like, and yet not quite perfect, it triggers a revulsion in people rather than a sympathetic response. "The things that scare or repulse us are those that are sympathetically human in some respects, but markedly alien in others." [Grice, 1999]

This phenomenon is known as the Uncanny Valley. [Reichardt, 1978] First coined by Masahiro Mori of the Tokyo Institute of Technology, this phrase refers to a graph showing the correlation between similarity to human and familiarity to human. For the first part of the graph, as a machine grows more similar to a human, it becomes more familiar. For example, a cartoon character is more similar and familiar than a smiley face, which in turn is more familiar and similar than a circle. However, at a certain point, an increase in the similarity to a human correlates to a very strong drop in familiarity.



The Uncanny Valley [from Reichardt 1978]

For example, a corpse is much less sympathetic than a cartoon character.

The Frankenstein monster, created by Mary Shelley, is the epitome of this phenomenon. Created to be a new life, it was instead a monstrosity that triggered the worst kind of revulsion in people. Frankenstein is the modern symbol of technology gone awry. Scientists' creative urges (and in fact many of my own projects) often tread on the shaky ground that is too-close-to-human.

Vampires and other undead creatures are abominations for a similar reason - they are like humans, but not quite. In fact, the very word "undead" captures our difficulty in categorizing these fantastic creatures. In order for people to conceive of them, it was necessary to craft an entirely new word, one that is essentially a double-negative.

James in front of his Giant Peach

An example of the Uncanny Valley from the animation world was related to me by Henry Selick, the director of the stop-motion animated film *James and the Giant Peach* [1996]. He told of the development process of the James character, who had to be changed to be less realistic after a few days of shooting, because the test footage came back and gave audiences a creepy feeling that they were watching a dead child crawling around the set. Even with the enlarged and simplified head that finally made it into the film, James is still a bit eerie.

Abominations arise from a failure to properly categorize something. "The idea of machinery with a conscious mental inner life frightens or enrages some people - an understandable visceral reaction, as the concept clashes with a deep primordial view on the nature of things." [Moravec, 99] A creature that seems almost human is a conundrum for our pigeon-holing mechanism. Often, these difficulties arise from the Uncanny Valley - where things are in the gray area between matching and not matching an abstraction. Abominations also arise from objects that fit multiple categories that were thought to be mutually exclusive.

An example of this from the non-human realm came during a fishing trip I took a few weeks ago. While wandering along between a road and a stream that run parallel to each other, I happened upon the decaying corpse of a Rottweiler, half wrapped in a trash bag. It was appalling to find a dead dog at all, but even more so to have it be treated as trash. I was perplexed by trying to categorize something simultaneously as a corpse and as garbage. It did not seem to be *right*, somehow.

PROJECTS

Considering the triggers that allow us to recognize living things has brought up a myriad of possible projects. Ask anyone for a definition of life, grab a few key words, and craft a project around it. Fuzzy things that squeak. Anything that breathes. Something that begs for death.

Things That Jump

A whole bunch of little machines that jump up in the air when you approach. Walking through a bunch of them would be like walking in a field of high grass, watching the grasshoppers hop away.

Penguinoes

A colony of wind-up penguins, each of whom walks forward when it is near another penguin, and stands still when it is by itself. They would act like moving dominoes, since you could set them up in an elaborate configuration, then set one final piece in place that would start the whole system moving. (Inspired by the work of Rob Poor. (`http://www.media.mit.edu/~r`))

LegoVirus

A Lego Mindstorms (`http://www.lego.com`) robot that, when provided with Legos and motors, can make another one of itself. (Imagine setting one loose on the Lego factory. A physical virus!)

Kill-Me Robots

Robots that beg for death. A whole squadron of them, limping piteously toward anything that moves near them, moaning "Kill Me!" Big red buttons on their backs, that, when pressed, cause them to sink to the floor with a sigh, and not move any more.

Schroedinger's Box

A closed cardboard box that emits scratching noises, like something trying to escape. When a person opens the box, the scratching stops. The box is empty.

Synthetic Characters Research

In fact, all the research that goes on in the Synthetic Characters Group is based on these triggers. Our creatures are based on the study of animal behavior. By looking at animals, scientists have arrived at theories about how animals work. Now we're trying to make creatures that satisfy the same theories. Our creatures strive to survive, they squawk, they react to their environment. They offer up behavior to the people who interact with them. Hopefully, they come alive in the eyes, ears, and hands of those people.

The Synthetic Characters' Chicken

However, an awareness of the Uncanny Valley should always be kept firmly in mind. Perhaps something with a face isn't upsetting, and something that

talks isn't upsetting, but something with a face that talks, but the lips don't move quite right is very upsetting to an audience. Elements that make something life-like may not recombine in a strictly linear fashion.

Ultimately, in the Synthetic Characters Group, we're taking tiny steps toward making a new form of life.

ACCEPTANCE

Human society determines whether something is alive. The dominant society in a culture often claims that their opinion is the *truth*. Religions invoke gods, scientists invoke natural laws, politicians invoke the Constitution. An object is alive in a society if it is treated like it is alive. For sentient machines, virtual creatures and other beings created by technology, coming-to-life will occur gradually, as their status is recognized by the dominant paradigm. "It may be appropriate to say 'God' has granted a soul to a machine when the machine is accepted as a real person by a wide human community." [Moravec, 99]

Metropolis

In order for a human society to be willing to accept a new form of life, these creatures need to be similar to things we already acknowledge as alive. They must develop similar complexity in anatomy and behavior. Once they have functionality and appearance that seem to qualify for life, however, they are only half-way there.

The second and more capricious stage of machines gaining life is their being accepted by human society. Throughout history, people have denied things that now seem obvious. Slaves were not 3/5 of a person. But that was how they were seen by the law and by slave-owners. Just so, machines that are nearly identical in function and appearance to living things may be denied the title "alive" because of their human-constructed origins.

The mass media is helping to lay a dubious groundwork for synthetic life. Beginning with the robot Maria in Fritz Lang's *Metropolis* [1927] and proceeding through *The Matrix,* [Wachowski and Wachowski, 1999], film and television have produced a long lineage of human-imitating machines in movies.

Space Odyssey [Kubrick,1968], is a space ship's sentient computer. While he st and a purely virtual being with only a large red eye, he certainly has the most

character of any of the characters in that film. He dies singing "A Bicycle Built for Two" in a tragic scene as his chips are removed. By making him the most interesting character in the film, Kubrick and author Arthur C. Clarke started a trend toward powerful and effective machine characters.

C3PO

• *Star Wars* [Lucas, 1977], its sequels [Kershner, 1980], [Marquand, 1983] and its prequel [Lucas, 1999] have consistently shown R2D2 and C3PO in a favorable light, as comic relief characters with independent personalities. They lack complex, fleshed-out personalities, and are often treated like talking pets. While they are occasionally put in grave danger and seriously damaged, they have yet to die.

• *Blade Runner* [Scott, 1982] stars Harrison Ford as a man who makes a living hunting down replicants (synthetic humans), who have been forbidden from living on Earth. The replicants have come to earth to meet their makers. The head replicant saves Harrison Ford's life just before the synthetic human's four-year life span expires. At the end of the director's cut, it is left unresolved whether Harrison Ford's character himself is a replicant. *Blade Runner*, more than most of its predecessors that portrayed machine life, dealt with the complex issues surrounding the prospect of creating intelligent, emotional, powerful machines. While they are set up as the enemies of society, they are simply seeking self-preservation and self-understanding.

These are just a few of the most popular examples of machines that simulate life in film. Other cases of intelligent machines and cyborgs include the *Alien* movies [Scott, 1979] [Cameron, 1986] [Fincher, 1992] [Jeunet, 1997], *The Terminator* films [Cameron, 1984] [Cameron, 1991], *Robocop* [Verhoeven, 1987] and *Star Trek: The Next Generation* [1987-94]. As Steven Johnson put it in his book *Interface Culture*, "The automaton-passing for human trope is as familiar to our collective storytelling habits as the mistaken-identity tropes of the sitcom or the false endings of the whodunit." [Johnson, 1997]

By putting machines in starring roles and allowing them to play both good guys and bad guys (just like people), these films and television help establish machines as future members of our own human society. In some cases, their deaths are the most tragic moments in the films.

People of a certain age may never accept machine life on an equal footing with biological life. Coming generations, though, will have been primed by films, television shows, video games, and home computers. There will not be a moment when machines are suddenly seen as being alive. Synthetic life will gradually seep into the collective conscious. Children will grow up around synthetic life, and not understand when their parents try to explain that "the robot's not alive, honey." By the end of *that* generation, machine life will be common knowledge.

Computers can only be fully alive when society treats them as such. Until then, digital creatures will remain *artificial* life.

ENDS

"Be careful what you pretend to be, because in the end, you are what you pretend to be."

Kurt Vonnegut
Mother Night

In the Synthetic Characters Group, we're making machines that mimic life. We design intelligent systems, and the best examples we have are the biological creatures around us.

Intelligent systems are inevitably complex. If a system is sufficiently complex, it is less important to understand its inner workings, and more useful to think of the system as a black box, that takes inputs and

provides outputs. Thinking of complex machines as living beings may be the best way of dealing with them. And eventually, if it is more useful to think of machines as alive, we'll forget to discriminate between machine life [Harrison and Minsky, 1992] and biological life.

Why do we want to create things that are alive, anyway? Perhaps it is the good-old-fashioned procreative urge. Perhaps it is simply a desire to make things that are useful and interesting, and the bulk of simple useful things have already been created. Maybe we're geeks with nothing better to do with our time.

Why is it better for these things to be acknowledged as alive than not-alive? Because it easier for people to deal with them. Thinking of a hammer's personality is probably not going to make it easier to use. With my personal computer, though, I often find it beneficial to think that it doesn't "like" having a certain batch of programs running at the same time.

If machines become truly alive, must we grieve when they die? Is it murder to destroy one? Or is it "putting to sleep"? Could we send them into mine shafts and wars and space and a host of other inhospitable climates, where they will suffer near-certain death? Or could we program them to feel deep joy at the consummation of their in-built purpose? While humans rejoice in having children, machines might achieve nirvana by serving humanity so well, even unto death, that people will be prone to making more copies of them at a later date. Humans are the mechanism of artificial selection in the digital realm. Ultimately, in the evolution of machine life, the "fittest" blueprints are those that most effectively serve humans. Animals need to reproduce before they die. Machines might enable their own reproduction *by means of* their own deaths.

Would we get jealous if machines were as smart as us and did not die? While some species of machine life might benefit us through their deaths, others might be made specifically never to die. Intelligent power-grids, which guarantee uninterrupted service to hospitals or whole communities, would evolve to be immortal. Can human pride tolerate machines that outlive us, and possibly, someday, out-think us? Only if we're not in competition. A possible solution might be to create a machine each time a person is born, and destroy that machine when that person dies. Then give the machine a desire not to die. If the machines were smart enough, they'd cure all human ills, and both species, human and machine, would become immortal. (Of course, right now, I have a hard enough time getting the *&)(*^@ printer to work...)

Like General Electric, I want to "bring good things to life." For now, though, computers aren't alive. Everybody knows that. Everyone knew the earth was flat, too.

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