The Singularity Is Near

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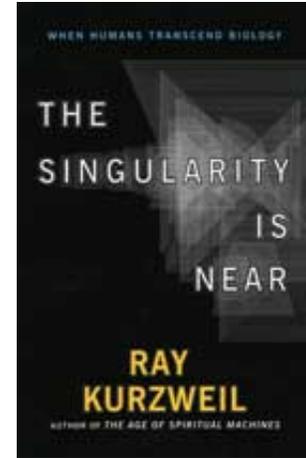
The Singularity Is Near: When Humans Transcend Biology is a 2005 update of Raymond Kurzweil's 1999 book, *The Age of Spiritual Machines* and his 1990 book *The Age of Intelligent Machines*. In it, as in the two previous versions, Kurzweil attempts to give a glimpse of what awaits us in the near future. He proposes a coming technological singularity, and how we would thus be able to augment our bodies and minds with technology. He describes the singularity as resulting from a combination of three important technologies of the 21st century: genetics, nanotechnology, and robotics (including artificial intelligence).

Four central postulates of the book are as follows:

1. A technological-evolutionary point known as "the singularity" exists as an achievable goal for humanity.
2. Through a law of accelerating returns, technology is progressing toward the singularity at an exponential rate.
3. The functionality of the human brain is quantifiable in terms of technology that we can build in the near future.
4. Medical advancements make it possible for a significant number of his generation (Baby Boomers) to live long enough for the exponential growth of technology to intersect and surpass the processing of the human brain.

Kurzweil's speculative reasoning and selective use of growth indicators has been heavily debated and challenged. (See criticisms at Technological Singularity) In response to this, in the last chapter he gives responses to some of the criticisms he has received.

The Singularity Is Near: When Humans Transcend Biology	
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Contents

Postulates

Acceptance and striving for the idea of living forever

Kurzweil asserts that a technological-evolutionary jump known as "the singularity" will be recognized as an achievable goal by humanity. Kurzweil acknowledges that *belief* in the singularity promotes the paradigm shift necessary for its advancement. By promoting the "truth" of its coming through predictions that seem remarkable at the time but inevitable after the fact (a global computer network, a computer beating the chess champion, etc.), Kurzweil's popular series of books reinforces the belief that a singularity is unavoidable.

The law of accelerating returns

Kurzweil asserts in his Law of Accelerating Returns that technology is progressing toward the Singularity at an exponential rate, relying almost entirely on empirical data. He expands on Moore's Law with models showing that not only the return, but the *rate* of return is increasing exponentially.

An objective measurement of cerebral processing power

Kurzweil asserts that the functionality of the brain is quantifiable in terms of technology that we can build in

the near future. Kurzweil's earlier books showed cerebral processing power as primarily the number of computations in a square inch multiplied by the area of the brain. In *this* update, however, he acknowledges the possibility of Penrose-Hameroff Microtubule quantum processing (Orch-OR) and states that if his calculations of the processing capability of the brain are off by a factor of a billion, the double-exponential growth of technology will still catch up to it twenty-four years after his original projections. The Orch-OR theory is generally discredited among neuroscientists.

In a rebuttal paper,[1] Hameroff asserts that the quantum processing power required for consciousness is at an order of magnitude greater than can be expressed through conventional systems of processing measurement. This argument seems to ignore Kurzweil's premise that accelerating returns in development of present technologies could, in a nominal period, overcome such a barrier. Additionally, other technologies could emerge which greatly lower the time required to reach the Singularity. A notable example would be more advanced forms of quantum computing capable of full neural emulation, which on a large enough scale, could function equivalently to the biological human brain.

Sufficient medical advancements

Kurzweil asserts that medical advancements will keep his generation alive long enough for the exponential growth of technology to intersect and surpass the processing of the human brain. Kurzweil explains how nanobots will eventually be able to repair and replace any part of the body that wears out, but relies on other methods of medical technology to prolong our lives long enough to reach the singularity. The usefulness of this medical postulate then becomes a function of how long it will take to reach the singularity, something that has been thrown into question due to the possibility of quantum brain processing explored in many recent books by scientists, such as Roger Penrose's *The Emperor's New Mind*.

Organization

- Prologue: The Power of Ideas
- Chapter 1: The Six Epochs
- Chapter 2: A Theory of Technology Evolution
- Chapter 3: Achieving the Computational Capacity of the Human Brain
- Chapter 4: Achieving the Software of Human Intelligence
- Chapter 5: GNR (genetics, nanotech, robots)
- Chapter 6: The Impact
- Chapter 7: Ich bin ein Singularitarian
- Chapter 8: The Deeply Intertwined Promise and Peril of GNR
- Chapter 9: Response to critics
- Epilogue

Chapter One: The Six Epochs

Kurzweil first defines the Singularity as a point in the future when technological advances begin to happen so rapidly that normal humans cannot keep pace, and are "cut out of the loop." Kurzweil emphasizes that this will have a profound, disruptive effect on human societies and on everyday life, and will mark the end of human

history as we know it. In place of normal humans, Strong Artificial Intelligences and cybernetically augmented humans will become the dominant forms of sentient life on the Earth. The Singularity will be initiated once self-improving Artificial Intelligences (sentient, highly intelligent computer programs capable of quickly redesigning themselves and their offspring to improve performance) come into existence.

Underlying all of Kurzweil's ideas regarding the progress of technology and the Singularity is the Law of Accelerating Returns. The Law states that technological progress occurs exponentially instead of linearly, meaning that each new advancement enables several higher advancements instead of just one higher advancement, and concordantly, every year, more useful inventions and discoveries are made than were made in the last.

The Law of Accelerating Returns has a very important consequence in that extrapolation of exponentially improving technology trends into the future suggests, by Kurzweil's analysis, that highly advanced technologies will arrive far sooner than linear-thinking people assume. The creation of the modern Internet and the completion of the Human Genome Project are prominent examples illustrative of this point. Both were multi-year projects that relied on computer technology to reach completion. In both cases, critics derided them as hopeless since, in the beginning, both relied on computers that would have taken decades to process all of the necessary data. However, these critics had failed to take into account the exponentially improving nature of computer processing speeds and price-performance, and thus failed to see that, within a few years, the two projects would have access to vastly superior computers that would drastically shorten their timelines for completion.

Kurzweil lays forth his idea that the fate of the universe is to progress through six different epochs, characterized by the major paradigm shift that takes place after each one. The universe has already passed through four of these epochs and we are entering epoch five. Each step indirectly produces the next through chemical-, biological-, and technological Evolution (respectively). The Six Epochs are subject to the Law of Accelerating Returns, which states that each transition occurs more rapidly than the last. Kurzweil supports this final postulate with logarithmic graphs of the chronology of important events in the history of the Universe (i.e. - the Big Bang, the origin of life, the birth of the human race, the creation of the first computer).

Epoch 1. Physics and Chemistry

This epoch starts at the beginning of the universe. In this epoch, information is mostly held in subatomic structures such as particles and atoms. That is, the most complicated stable objects in the universe do not exceed the molecular scale in size or complexity.

Epoch 2. Biology and DNA

This epoch starts with the beginning of life on Earth, suddenly giving rise to more complicated, yet stable, organisms that are capable of growth and self-sustainment. However, in this epoch organisms do not change within their lifetimes as evolution takes thousands of generations. Moreoever, in this stage, genetic information is stored in DNA molecules.

Epoch 3. Brains

The evolution of life gradually produced more and more complex organisms, necessitating the need for fast

central control and thus giving rise to the evolution of brains. With brains, organisms can now change their behavior dynamically to suit changes in the environment and can also learn from past experiences. Evolutionary information is, in this stage, stored in neural patterns.

Epoch 4. Technology

Evolution of brains culminates with the evolution of humans, which possess the ability to create technology. In this stage, technological designs are also subject to evolution and information is held in hardware and software designs.

Epoch 5. The Merger of Human Technology with Human Intelligence

This epoch, which Kurzweil argues we are in the process of entering, is where technology reaches a level of sophistication and fine-structuring comparable with that of biology, allowing the two to merge to create higher forms of life and intelligence.

Epoch 6. The Universe Wakes Up

After mastering the methods of technology and biology, Kurzweil predicts that human/machine civilization will expand its frontiers into the universe, gradually (or perhaps explosively) consuming the contents of the cosmos until the universe reaches a 'saturated' state where all inanimate matter has been converted to substrates for computation and intelligence, and a truly universal super-intelligence takes form.

Next, Kurzweil briefly lays out a number of postulates and consequences in the first chapter as they relate to the Singularity. As stated, the Law of Accelerating Returns implies exponential- and non-linear growth in technological capabilities and human knowledge. Information technologies are experiencing superexponential growth since human economic investment in them increases as they become more powerful.

Human brain-scanning techniques are reliant upon computers and advanced machines, which are all subject to the Law of Accelerating Returns. Therefore, our ability to understand the way the human brain works is improving tremendously every year. Based on the current trends, brain scans should give us a sound understanding of how the human brain works by the mid-2020s. Using that information, scientists should be able to create simulated human brains inside of computers, leading to the first Artificial Intelligence (a thinking computer capable of passing the Turing Test) by 2029. The computer hardware of that era should also be powerful enough to meet the cognitive needs of a simulated human mind.

Artificial Intelligence would inevitably prove superior to human intelligence since the former would combine the fast speeds, memory capacity and recall, and instant downloading/learning abilities of computers with the creativity and pattern-recognition abilities of the human mind, effectively constituting a being with the strengths of both and the weaknesses of neither. Artificial Intelligences would also have the ability to edit their own software at will to instantly improve themselves, which is an ability humans naturally lack and can only approximate through laborious genetic engineering techniques.

Biology presents inherent and insurmountable limitations that originate at the molecular level. These limitations handicap both potential mental abilities and physical abilities. This reality will inevitably lead to the creation of synthetic replacement parts that are far more durable and capable than natural human organs, limbs

and cells. Some humans will choose to incorporate these engineered prostheses into their bodies, becoming cybernetically enhanced.

Nanotechnology will play a major role in human brain augmentation with the advent of brain nanomachines designed specifically for interacting with human neurons. Brain cybernetics of this type would allow human users to vastly expand their cognitive abilities, to experience full-immersion virtual reality, and to directly interface with computers and other mentally augmented humans. Being naturally more powerful, the cybernetic portion of augmented human minds will come to predominate.

A very broad range of advanced nanomachines will also be created, allowing the humans and machines of the future to alter their world with incredible power. Aside from the aforementioned brain augmentation role, nanotechnology could be used for a variety of tasks including a total repair of the Earth's environment and the near instantaneous manipulation of physical objects via foglets so as to blur the distinction between "real" and "virtual" reality.

Kurzweil foresees the computers of the future using three-dimensional computer chips composed of nanotubes. This architecture will allow them to operate at terahertz speeds. Computer advances like this will eventually make A.I.'s so powerful that they will completely take over the cutting edge of all scientific research and development, and will generate new advancements (including improvements to their own programming) so quickly that normal humans will not be able to follow what is going on. By this point, the Singularity will definitely have been reached.

In the far future, A.I.'s and cybernetic humans will live almost exclusively in full-immersion virtual reality worlds, which will themselves be contained in advanced computers. Computers will grow ever more advanced, but at some point, the bottom limit to transistor size as defined by the laws of Physics will be reached, and performance improvements will only be possible through the creation of new computers or the expansion of existing ones. More and more inanimate matter on the Earth will be restructured to form useful computer substrate, but it will eventually prove insufficient, and the future machine race will radiate out from the Earth in all directions, "saturating" first the solar system, then the Milky Way galaxy, and eventually the entire cosmos with "intelligence" by converting unstructured, inanimate "dumb" matter (e.g., Moon rocks, dead gas giant planets, meteoroids) into structured "smart" matter that lives in the sense that it supports thinking, feeling A.I.'s. Entire celestial bodies of countless number across the universe will be totally converted into computer substrate. The length of time it will take to finish the task of "waking up" the universe depends heavily on whether the speed of light can be surpassed or circumvented—the maximum rate of travel of course limiting the speed at which the advanced Earth civilization can spread across space to new locations.

Kurzweil concludes the chapter by stating his belief that, while A.I.'s will inevitably prove vastly superior to humans in every way, he expects them to respect human life and to embody human values.

Chapter Two: A Theory of Technology Evolution

Each stage of biological evolution and technological innovation increases the level of biological or technological order and enables entry into the next stage. Order in this case is defined as how well the form (genetic or physical) suits the given function. For example, a modern car is better suited for transporting human occupants than a Model T because the newer vehicle possesses numerous design improvements the

older one lacks.

An increase in order also generally correlates with an increase in complexity. Getting back to the previous example, a modern car has more moving parts than a Model T, and the newer car's parts are also more precisely and elaborately made. Thus, the modern car is more complex. The overall trend towards increasing complexity can also be observed in biology, where genomes of living species have gradually grown in size along with levels of physical diversity and specialization.

Of course, greater order does not necessarily always entail greater complexity. Sometimes, the simpler solution proves superior both in biology and technology, but the general trends in both have been towards more complexity and more order.

The Law of Accelerating Returns states that biological and technological evolution utilize positive feedback, with each improvement building upon the last and enabling the next.

Technological progress in any field consists of a series of "paradigms"—particular methods used to solve certain problems. A given example of a paradigm would be the shrinking of computer transistors to make the computers more powerful. While there are innumerable technological paradigms, all share the same basic life cycles. The advances in the cost-performance of a particular technology, or the Life Cycle of the Paradigm, if graphed, will appear as a sigmoidal S-shape with three distinct phases.

Slow Growth Phase
    At this point, the kinks in the technology are still being worked out, and it is still struggling to establish a market base. Growth in price-performance and capabilities is exponential, but still at such an early stage that the growth appears deceptively flat and linear.
Rapid Growth Phase
    Begins after the exponential growth passes the "knee of the curve" and explosive growth in the technology's capabilities and user base starts.
Leveling Off Phase
    The technology matures as scientists find it increasingly more difficult to make improvements to the same technology in an effort to further address the original need. Growth in usefulness levels off.

Once a technology has reached maturity, it is replaced by a newer, totally different technology, meaning a paradigm shift occurs. This occurred during the 1960s when scientists found it impractical to shrink computer vacuum tubes any further and instead switched to transistors, which were newer and allowed the process of miniaturization to continue.

This process of periodic exponential growth parallels biological evolution in two ways. First, biological evolution also occurs in spurts and, second, some biological innovations make organisms exponentially better or speed up evolution from that point onwards in an exponential manner. For example, the advent of DNA allowed life forms to evolve much higher levels of complexity and order.

Society's acceptance of new technologies is speeding up exponentially

- U.S. Phone company revenues and daily number of American phone calls (increasing exponentially)
- Number of U.S. cell phone subscribers (increasing exponentially)
- Time until major new inventions reach mass use by American consumers (decreasing exponentially)

Technologies experiencing exponential changes:

- Increasing exponentially:
    - Microprocessor clock speeds
    - Transistors per microprocessor
    - Processor performance
    - Dynamic RAM price performance (improving exponentially)
    - Random Access Memory bits per dollar
    - Magnetic data storage bits per dollar
    - Wireless Internet and phone services price performance
    - Number of Internet hosts
    - Bytes of Internet traffic
    - Internet backbone bandwidth (increasing in a very terraced, quasi-exponential manner)
    - Number of scientific citations for nanotechnology research
    - Number of U.S. nanotech patents

- Decreasing exponentially:
    - Average Transistor price
    - Transistor Manufacturing costs
    - Dynamic RAM size (smallest feature sizes decreasing exponentially)
    - Microprocessor costs
    - DNA sequencing costs per base pair
    - Mechanical device sizes

While Gordon Moore first observed in 1965 that the transistor densities of integrated circuits were doubling every two years, an extended analysis[citation needed] shows that computers have been experiencing exponential improvements to their cost-performance (maximum number of calculations per second per $1,000) since at least 1900, when the very first electromechanical computers were invented. This trend in increasing performance has held steady across five computer paradigm shifts (electromechanical, relay-based, vacuum tube, transistor, and integrated circuit) and is now encapsulated by Moore's Law. While integrated circuits will —like all paradigms—ultimately reach the limits of their possible capabilities, the exponentially growing performance trend will likely continue via a paradigm shift to a newer technology like memristors or three-dimensional molecular computing.

Extrapolating this rate of improvement, supercomputers should be capable of the same number of calculations per second as a human brain by 2010, and personal computers should be at this level around the year 2020. The amount of improvement in nanoscience at the same rate also see 2020 as a nexus point.

Predictions

2010

- Supercomputers will have the same raw power as human brains (although not yet the equivalently flexible software).
- Computers will disappear as distinct physical objects, being embedded in clothing and in everyday

objects.

- Displays built into our eyeglasses will provide full-immersion audio-visual virtual reality.

2010s

- Computers become smaller and increasingly integrated into everyday life.
- More and more computer devices will be used as miniature web servers, and more will have their resources pooled for computation.
- High-quality broadband Internet access will become available almost everywhere.
- Eyeglasses that beam images onto the users' retinas to produce virtual reality will be developed. They will also come with speakers or headphone attachments that will complete the experience with sounds. These eyeglasses will become a new medium for advertising as advertising will be wirelessly transmitted to them as one walks by various business establishments.
- The VR glasses will also have built-in computers featuring "virtual assistant" programs that can help the user with various daily tasks. (see Augmented Reality)
- Virtual assistants would be capable of multiple functions. One useful function would be real-time language translation in which words spoken in a foreign language would be translated into text that would appear as subtitles to a user wearing the glasses.
- Cell phones will be built into clothing and will be able to project sounds directly into the ears of their users.
- Advertisements will utilize a new technology whereby two ultrasonic beams can be targeted to intersect at a specific point, delivering a localized sound message that only a single person can hear. This was fictionalized in the films *Minority Report* and *Back to the Future Part II*. See Sound from ultrasound.

2014

- Automatic house cleaning robots will have become common.

2018

- 10 Terabits (10^{13} bits) of computer memory—roughly the equivalent of the memory (RAM) space in a single human brain—will cost $1000.

2020

- Personal computers will have the same processing power as human brains.

2020s

- Computers less than 100 nm in size will be possible.
- As one of their first practical applications, nanomachines will be used for medical purposes.
- Highly advanced medical nanobots will perform detailed brainscans on live patients.
- Accurate computer simulations of the entire human brain will exist due to these hyperaccurate brainscans, and the workings of the brain will be understood.
- Nanobots capable of entering the bloodstream to "feed" cells and extract waste will exist (though not

necessarily be in wide use) by the end of this decade. They will make the normal mode of human food consumption obsolete. Thus, humans who have injected these nanobots into their bloodstream will evolve from having a normal human metabolism and become humanoid cyborgs. Eventually, according to Kurzweil, a large percentage of humans will evolve by this process into cyborgs.

- By the late 2020s, nanotech-based manufacturing will be in widespread use, radically altering the economy as all sorts of products can suddenly be produced for a fraction of their traditional-manufacture costs. The true cost of any product is now the amount of time it takes to download the design schematics.
- Also by the later part of this decade, virtual reality will be so high-quality that it will be indistinguishable from reality.
- The threat posed by genetically engineered pathogens permanently dissipates by the end of this decade as medical nanobots—far more durable, intelligent and capable than any microorganism—become sufficiently advanced.
- A computer will pass the Turing test by the last year of the decade (2029), meaning that it is a Strong AI and can think like a human (though the first A.I. is likely to be the equivalent of a kindergartner). This first A.I. is built around a computer simulation of a human brain, which was made possible by previous, nanotech-guided brainscanning.

2025

- The most likely year for the debut of advanced nanotechnology.
- Some military UAVs and land vehicles will be 100% computer-controlled.

2030s

- Mind uploading becomes possible.
- Nanomachines could be directly inserted into the brain and could interact with brain cells to totally control incoming and outgoing signals. As a result, truly full-immersion virtual reality could be generated without the need for any external equipment. Afferent nerve pathways could be blocked, totally canceling out the real world and leaving the user with only the desired virtual experience.
- Brain nanobots could also elicit emotional responses from users.
- Using brain nanobots, recorded or real-time brain transmissions of a person's daily life known as "experience beamers" will be available for other people to remotely experience. This is very similar to how the characters in *Being John Malkovich* were able to enter the mind of Malkovich and see the world through his eyes.
- Recreational uses aside, nanomachines in people's brains will allow them to greatly expand their cognitive, memory and sensory capabilities, to directly interface with computers, and to telepathically communicate with other, similarly augmented humans via wireless networks.
- The economy transits in GDP percentage to more meta services such as reality fabrication, mind enhancement, mental software.
- The same nanotechnology should also allow people to alter the neural connections within their brains, changing the underlying basis for the person's intelligence, memories and personality.

2040s

- Human body 3.0 (as Kurzweil calls it) comes into existence. It lacks a fixed, corporeal form and can

alter its shape and external appearance at will via foglet-like nanotechnology. Organs are also replaced by superior cybernetic implants.

- There will be social splitting into different levels of use of reality augmentation, from those who want to live in a life of imagined harems, or those who dedicate their thoughts to philosophical extension. Human society will drift apart in its focus, but with ever increasing capabilities to make imagined things occur.
- People spend most of their time in full-immersion virtual reality (Kurzweil has cited *The Matrix* as a good example of what the advanced virtual worlds will be like, without the dystopian twist).
- Foglets are in use.

2045: The Singularity

- $1000 buys a computer a billion times more powerful than the human brain. This means that average and even low-end computers are hugely smarter than even highly intelligent, unenhanced humans.
- The Singularity occurs as artificial intelligences surpass human beings as the smartest and most capable life forms on the Earth. Technological development is taken over by the machines, who can think, act and communicate so quickly that normal humans cannot even comprehend what is going on; thus the machines, acting in concert with those humans who have evolved into postbiological cyborgs, achieve effective world domination. The machines enter into a "runaway reaction" of self-improvement cycles, with each new generation of A.I.s appearing faster and faster. From this point onwards, technological advancement is explosive, under the control of the machines, and thus cannot be accurately predicted.
- The Singularity is an extremely disruptive, world-altering event that forever changes the course of human history. The extermination of humanity by violent machines is unlikely (though not impossible) because sharp distinctions between man and machine will no longer exist thanks to the existence of cybernetically enhanced humans and uploaded humans.

Post-2045: "Waking up" the Universe

- The physical bottom limit to how small computer transistors can be shrunk is reached. From this moment onwards, computers can only be made more powerful if they are made larger in size.
- Because of this, A.I.s convert more and more of the Earth's matter into engineered, computational substrate capable of supporting more A.I.s. until the whole Earth is one, gigantic computer (but some areas will remain set aside as nature preserves).
- At this point, the only possible way to increase the intelligence of the machines any further is to begin converting all of the matter and energy in the universe into similar massive computers. A.I.s radiate out into space in all directions from the Earth, breaking down whole planets, stars, moons and meteoroids and reassembling them into giant computers. This, in effect, "wakes up" the universe as all the inanimate "dumb" matter (rocks, dust, gases, etc.) is converted into structured matter capable of supporting intelligence, or a form of synthetic life.
- Kurzweil predicts that machines will have the ability to make planet-sized computers by 2099, which underscores how enormously technology will advance after the Singularity.
- The process of "waking up" the universe will be complete as early as 2199.
- With the entire universe made into a giant, highly efficient supercomputer, A.I./human hybrids (so integrated that, in truth it is a new category of "life") would have both supreme intelligence and physical control over the universe. Kurzweil suggests that this will open up all sorts of new possibilities, including manipulation of the physical constants, inter-dimensional travel, and

controlling the fate of the universe.

Some indeterminate point within a few decades from now

- Space technology becomes advanced enough to provide the Earth permanent protection from the threat of asteroid impacts.
- The antitechnology "Luddite" movement will grow increasingly vocal and possibly resort to violence, possibly a new World War, as these people become enraged over the emergence of new technologies that threaten traditional attitudes regarding the nature of human life (radical life extension, genetic engineering, cybernetics) and the supremacy of mankind (artificial intelligence). Though the Luddites might, at best, succeed in delaying the Singularity, the march of technology is irresistible and they will inevitably fail in keeping the world frozen at a fixed level of development. However, some nature preserves may be set aside for them to live in.
- The emergence of distributed energy grids and full-immersion virtual reality will, when combined with high bandwidth Internet, enable the ultimate in telecommuting. This, in turn, will make cities obsolete since workers will no longer need to be located near their workplaces. The decentralization of the population will make societies less vulnerable to terrorist and military attacks.

Film Adaptations

In 2006 Barry Ptolemy and his production company Ptolemaic Productions licensed the rights to *The Singularity Is Near* from Kurzweil. Inspired by the book, Ptolemy would direct and produce the film Transcendent Man which would go on to critical and commercial success in 2011 bringing more attention to the book.

Translations

- Chinese translation: 奇点迫近
- Italian translation: La singolarità è vicina
- Korean translation: 특이점이 온다

See also

- Singularitarianism
- Transhumanism
- Limits to computation
- Paradigm shift
- Simulated reality
- Technological singularity
- Timeline of the future in forecasts
- Transcendent Man

References

1. **^** Source: KurzweilAI.net (http://www.kurzweilai.net/articles/art0183.html?m=3)

External links

- Singularity.com, including reviews of the book and articles about Kurzweil (http://www.singularity.com)
- Vice Magazine interview with Ray Kurzweil (http://www.viceland.com/int/v16n4/htdocs/ray-kurzweil-800.php)
- Documentary- The Singularity of Ray Kurzweil on YouTube (http://www.youtube.com/watch?v=cc5gIj3jz44)
- Hameroff at KurzweilAI.net (links to essays related to Singularity) (http://www.kurzweilai.net/meme/frame.html?main=/meme/memelist.html?m%3D3)
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- *Brain Chips and Other Dreams of the Cyber-Evangelists* by John Horgan (http://www.johnhorgan.org/work13.htm)
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- *IEEE Spectrum details the topic (6/2008)* includes his keynote (http://spectrum.ieee.org/singularity)
- Aubrey de Gray, British researcher on aging, claims he has drawn a roadmap to defeat biological aging. (http://www.ted.com/speakers/aubrey_de_grey.html)

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