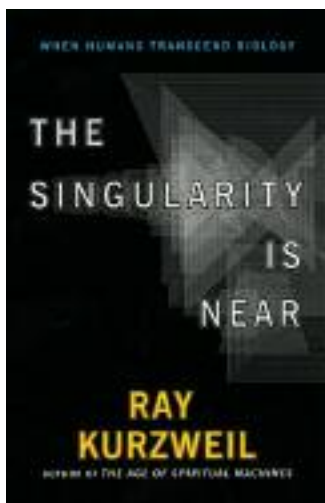# The Large and Small Powers of Ten: Accelerating Towards Kurzweil's Singularity

by Matt Jolly
University of Advancing Technology

Even if Ray Kurzweil is only half right then this book is a worthwhile read even if it only functions as a roadmap for navigating the future world or worlds.

Book Review:
Ray Kurzweil, *The Singularity Is Near: When Humans Transcend Biology*, Viking Penguin, 2005, ISBN 067003847, 652 pages, US$29.95

My wife and I had moved into a new home at the same time that I was contemplating the direction of this book review. One of our initial needs was the purchase of a new refrigerator, which we accomplished at a Sears scratch-and-dent store near our new home. We discovered, on the day after its installation, that the derelict fridge was broken—the compressor would kick on, overheat within seconds, and almost immediately shut down. I called Sears to inquire about the problem and to schedule a repair. I found myself in the tangled mess of those standard voice-recognition services that required me to dutifully listen to the layers upon layers of lists, attending to the most appropriate possible selection number (sometimes revising it if a more accurate option emerged), and then imitating (in ape fashion) the exact word or phrases that would lead me to the next level of selections. Whenever I encounter one of these systems, my single-minded goal is to find the shortest route to a breathing customer service representative at the other end. I managed to schedule an appointment,

but only after unintentionally eddying in the warranty section of the information system.

On the day of my scheduled repair, I called again to confirm my appointment and to get a rough estimate of the technician's arrival time. This time, the machine on the other end asked me an open-ended question: "What can I help you with today?" I was momentarily caught in an anxious silence. I knew that this machine possessed a limited vocabulary, and I felt some pressure to find the right answer. I tried to anticipate the limited catalog of possible responses, a sort of small scale reverse engineering project; after all, the root menu of these voice-recognition systems are usually the largest boxes (options) within which the more granular ends are contained—they are equivalent to the roman numeral headings of the outline, or the root folder in the operating system. I couldn't help but imagine myself doomed to some limbo of the automated operator universe, trying to guess what command the computer needed to hear.

"Repair?"
"I'm sorry, I don't recognize that option. Please try again. What can I help you with today?"
"Technician?"
"I'm sorry, I don't recognize that option. Please try again. What can I help you with today?"
"Canada? Potato chips. . .?"

In the interim, while I struggled to process the range of possible answers, the machine repeated its question. "Service appointment," I said, feeling flustered and unsure of my answer. "Are you looking for parts and repair?" it asked. She (the machine) had a pleasant voice. I felt soothed. "Yes," I told her. After the machine had collected my name and phone number, she explained that I had a scheduled repair visit that morning, and that I should be available between the times of 8:00 AM and noon. Well that was fine, but I was very busy, so I said, "Customer service." The machine said, "Please hold while I connect you to one of our customer service representatives."

The Service Representative (whose human voice was not nearly so soothing, but who was still very helpful) told me that I was the fifth scheduled visit for that morning and that the technician, whose name was Joe, was already at the second house. Apparently Joe was being tracked by a GPS system that knew his exact location based on the programmed addresses in relation to the progress of his vehicle. Five minutes later, I got a call from Joe (calling from his truck) to let me know he had received a message that I was ready and that he'd be by around 11:50. But the most amazing part about this story of intertwined artificial intelligence and customer service is that when Joe discovered the problem (a defective relay) he immediately knew whether or not he had the part based on the electronic inventory system that his service vehicle maintained

She (the machine) had a pleasant voice. I felt soothed.

for him. In other words, Joe consulted his van, and his van told him that he was in possession of the needed relay, and also knew the exact location where that particular part was stored. In the span of a single morning, I had interacted with a flexible artificial intelligence program—one that was capable of connecting related ideas—as well as a service repair team consisting of one human technician and one computer accountant.

This may seem a bit too much hyperbole, but since I've read Ray Kurzweil's *The Singularity is Near*, I have a heightened awareness of those moments when technology and humanity seem powerfully intertwined—particularly as that human

and technological collaboration connects to my own pedestrian experiences. In this, his fifth book, Ray Kurzweil predicts the arrival of a transcendent stage in human evolution (the singularity) accomplished through the accelerating development of genetics, nanotechnology and robotics (GNR). With significant research from both the popular and peer-reviewed spheres of publication, along with histori-

cal parallels, as well as with his own mathematical formulas and trends analysis, Kurzweil makes a fairly convincing argument (as far as prognostications go) for the inevitability of that transcendence. It is also a work that meaningfully confuses the lines between scientific speculation and religious prophecy. In the end, Kurzweil manages to confront some of the real challenges that we will face as a result of these increasing technological trends.

Kurzweil's singularity is "a future period during which the pace of technological change will be so rapid, its impact so deep, that human life will be irreversibly transformed" (p. 7). In other places, he defines it as a merging of humans and technology to the point where there is no longer any clear distinction between human biology and the technology that it has incorporated. He routinely admits that seeing past the "event horizon" of the singularity is impossible, which is certainly a fair assertion, but the vague definitions of that "event horizon" make it difficult to envision. It helps that he routinely incorpo-

rates imaginary dialogues (with both real and imaginary characters) in order to further clarify his ideas. These dialogues are playful exchanges, almost always involving a woman named Molly (also Kurzweil's companion in his previous book, *The Age of Spiritual Machines*). Other characters include Molly from 2104, George from 2048, Bill ("an environmentalist"), Sigmund Freud, Ned Ludd (the iconic namesake of the Luddite movement), as well as two bacteria (Futurist Bacteria and Friend of Futurist Bacteria). It is through these characters' interactions that we get a more complete vision of Kurzweil's singularity. Characteristics of that future include immortality, the complete absence of an original biological body (consciousness, instead, exists within the "mesh" or web), the ability to manifest different forms in both real and virtual worlds using a variety of techniques, the potential for the direct emotional and intellectual experience of others (a sort of perfect empathy), the ability to irrevocably merge with another consciousness (man or machine), and a seemingly boundless intellectual potential for both knowledge acquisition and knowledge synthesis. It is largely unfair of me to present that description of Kurzweil's future so early in this review, primarily because Kurzweil himself seems to deliberately withhold that information in *The Singularity is Near* long enough to lay the adequate foundations. My list of the characteristics of Kurzweil's future will seem to a reader like a catalog of science fiction tropes, interesting but easily dismissed. However, readers of Kurzweil's book will find those same conclusions far more difficult to shrug off, primarily because they are supported by a great deal of research, analysis, logic and expert opinion.

The Singularity is Near begins with a broad description of Kurzweil's six epochs of evolution: 1) Physics and Chemistry, 2) Biology, 3) Brains, 4) Technology, 5) Merger of Technology and Human Intelligence, and 6) The Universe Wakes Up. These epochs are more universal than human—after all, the timeline begins with the formation of the universe's physical laws and chemical reactions and humans really don't appear in

this timeline until the third epoch. Accordingly, we are squarely in the fourth epoch, Technology, with the fifth epoch (the beginning of the singularity) due in the mid-2040s. It might seem strange that we could have just entered the fourth epoch to find ourselves already transitioning into the fifth, but Kurzweil's constant assertion is that evolution follows a "historical exponential" trend rather than an "intuitive linear" one, "that is, it expands repeatedly multiplying by a constant" (p. 10). This exponential view relies on Kurzweil's Law of Accelerating Returns which he expresses both mathematically and descriptively. I'll stick to the descrip-

The Singularity is Near begins with a broad description of Kurzweil's six epochs of evolution.

tive: each evolutionary development capitalizes on previous developments resulting in a positive feedback loop where new technologies are more powerful and cost-effective than previous ones and necessarily allow for a speedier and more efficient development of the next generation of more powerful and cost-effective tech-
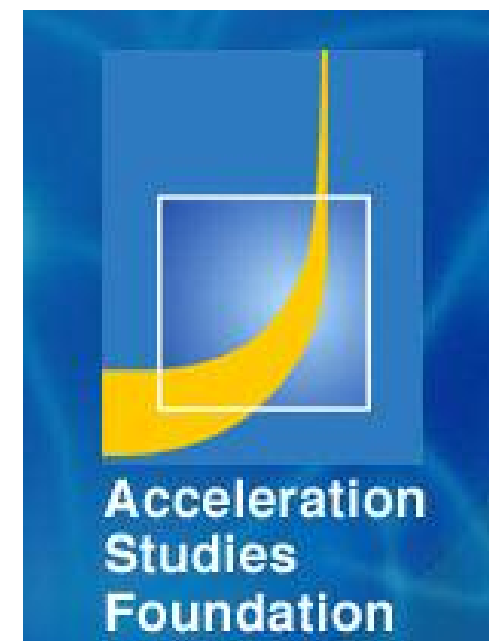

Figure 1. The logo of the Acceleration Studies Foundation is a graphical expression of an exponential curve. The boxed area draws particular attention to the knee of that curve as it relates to Kurzweil's sense of current and near-future technological advances.

nologies, etc., ad infinitum. In support of this assertion, Kurzweil conducts a brief but effective analysis of a number of recent technological developments, demonstrating an exponential (accelerating) trend in each. These analyses include: DNA sequencing by cost per base pair and by sequence data; Random Access Memory; price-performance of magnetic data storage; price-performance of wireless data services; number of internet hosts; Internet data traffic (bytes per year); Internet bandwidth (bits per second); miniaturization of mechanical devices; citations of nanotechnology in scholarly journals; and US Nano-related patents (pp. 73-84). In each case, Kurzweil demonstrates that these technologies are rounding the knee of the curve as they are graphed as exponential trends. This graphical concept is wonderfully echoed in the Acceleration Studies Foundation logo (Figure 1). The speed with which Kurzweil conducts this analysis is understandable. It's important to point out, however, that these graphs might as easily represent the lower half of an S-curve (the trend that most individual technologies follow). The significant difference between these two trends, of course, is that the S-curve has a ceiling, whereas the exponential growth does not. In most cases, a new technology sees the most growth in the middle of its life cycle, with a ceiling that results from a number of factors which may include the replacement of the technology by a more effective one, the achievement of maximum physical capability, a decrease in consumer interest, or due to changes in the technology environment outside the immediate scope of the technology itself. The graph for "Internet Hosts" is a prime example of an S-curve in its early stages—even if the number of hosts was to continue to accelerate at the current rate, it would eventually find the human population as a potential limit (i.e., its absolute maximum would be that point when each person on earth is their own internet host), although it's obviously likelier that a saturated market will limit that number much sooner.

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Kurzweil would not see this observation about S-curves as a criticism—in fact, the basis of his third chapter, "Achieving the Computational Capacity of the Human Brain," assumes the potential limits of current computation, and envisions computational technologies that might replace current silicon chip technologies. The handful that he offers up include "nanotubes and nanotube circuitry, molecular computing, self-assembly in nanobot circuits, circuit assembly emulating biological systems, spintronics, computing with DNA, computing with light, and quantum computing" (p. 112). Kurzweil places a lot of emphasis on nanotechnology as the likeliest next step in computing. For each of these technologies, he briefly explores the history of the developments and includes some examples of the most recent projects that have put these technologies to use. Perhaps the most complex computation he describes is that using quantum particles, where each particle would do double duty, being able to process both the 1 and the 0 (the on and off) simultaneously. He goes on to leverage these developments against the baseline requirements of computing at the level of the human brain. Three different estimates (based on computer models of the human retina, the auditory cortex and a region of the cerebellum) all yielded a total of between 10^{14} to 10^{15} computations per second (cps).

Kurzweil believes that the key to developing the software of the human brain can be achieved through the reverse engineering of our own biological wetware.

Kurzweil suggests that we will achieve that computational power by 2020. He arrives at an estimated date for the singularity by projecting this trend further: "By the mid-2040s… one thousand dollars worth of computation will be equal to 10^{26} cps, so the intelligence created per year (at a total cost of 10^{12} dollars) will be about one bil-

lion times more powerful than all human intelligence is today. That will indeed represent a profound change" (p. 137).

Kurzweil repeatedly refers to himself as an optimist, and most critics of his work have agreed (see Bill Joy's article in Wired: "Why the Future Doesn't Need Us," http://www.wired.com/wired/archive/8.04/joy_pr.html). But to his credit, he does a fine job of probing some of the potential limits of computation, most specifically energy and mass. His solutions to these problems rely largely on developing low-energy or zero-energy (cold computing) computers. Of course, his conclusion is that the actual ceiling of computation will not be reached until we run out of all energy and matter in the universe—a point that will not be reached for billions of years, that is unless we discover ways of traveling through wormholes, which would significantly reduce the time of complete takeover. This complete distribution of information throughout the universe constitutes Kurzweil's Sixth Epoch in evolution: The Universe Wakes Up.

Kurzweil believes that the key to developing the software of the human brain can be achieved through the reverse engineering of our own biological wetware. While current methods are relatively slow, their progress is also accelerating (yes, exponentially) so that the detail and speed of brain imaging will grant us a clear and complete picture relatively soon. He also recommends that (as yet undeveloped) nanobots will be capable of giving us everything we need to know about the fragile machinery of our minds. Perhaps the most fascinating aspects of this section are Kurzweil's comparisons of computer "thought" and human thought. In *The Age of Spiritual Machines*, Kurzweil explored these differences by comparing Deep Blue, the IBM computer that beat chess champion Gary Kasparov in 1997 (a feat that Kurzweil had predicted would not happen until 1998), to a human chess player. Deep Blue uses an analytical logic, building out logic trees that weigh the consequences of thousands of potential moves. The computer must consider good and bad moves equally. The human

player, however, uses "neuromorphic" approaches, pattern recognition, as a sort of logical razor to limit the moves that require consideration. Deep Fritz (a progeny of Deep Blue) has far less computing power, but is equipped with stored patterns that allow it to more closely imitate the brain's neuromorphic powers (pp. 274-78).

The bulk of Kurzweil's *Singularity* resides in the chapter entitled "GNR: Three Overlapping Revolutions." GNR stands for Genetics, Nanotechnology and Robotics. Robotics, in this sense, is not merely the mechanical claw that grabs the barrel of oil; the term also includes artificial intelligence on all levels—logical, emotional, spiritual. Each of the subsections examines the history, current projects and future trends of these emerging technologies. In this chapter, Kurzweil largely focuses on the potential benefits that will emerge, focusing on setbacks only when those setbacks are impossible to avoid. The benefits he enumerates include (to name just a few) the elimination of cancer and heart disease (leading to potential medical immortality); the end of world hunger; the preservation of endangered species and the restoration of extinct ones; environmental preservation and renewal; technological enhancement of all human activities (from thinking to communicating to lovemaking); and the development of interconnected global, and ultimately universal, information systems which could potentially subsume us. What's more, due to the benefits and potential inherent in this merger between technology and human biology, most of us will want to be subsumed.

One Amazon.com critic of *Singularity* has suggested that "This is an important book, but it is by a nerd for nerds… The book is, in short, divorced from the humanities and the human condition" (Steele). I would argue, instead, that Kurzweil recognizes the social and human impact that these technological revolutions would likely have on the population, but is interested instead, on focusing largely on the potential. His

audience is likely the developers of the technology, the scientists and technologists, more so than a technologically savvy but relatively casual reader like myself. I have a hard time thinking in powers of ten, particularly as Kurzweil approaches the incredibly large and the incredibly small. These are probably some of the limits of my own v1.0 brain. Still, I have to admit that I was much more enthusiastic about the chapters towards the end of the book: "The Impact," "Ich bin ein Singularitarian," and "The Deeply Intertwined Promise and Peril of GNR," and "Response to Critics." It is in these

sections that I find the most fascinating and profound challenges to my philosophies and self-image(s), and more particularly, challenges to my sense of unique (mysterious) selfhood and autonomy.

I am not a religious person, but I have always had some sense of myself as a unique, mysterious, and autonomous individual. Nietzsche wrote, in *The Gay Science*, that "the human being under the skin is to all lovers a horror, a blasphemy against God and love." That observation echoes, for certain, my own anxieties about the mechanical image of the brain that Kurzweil relies upon in order to speculate on the emergence of a truly strong "Strong AI." If the brain can be mechanically modeled and emulated as Kurzweil suggests, and if that results in something that we might refer to as human consciousness, then there must not have been any magic—any truly beautiful or terrifying mystery—in there to

begin with. Kurzweil argues: "As for our response to emotions and our highest aspirations, these are properly regarded as emergent properties—profound ones to be sure but nonetheless emergent patterns that result from the interaction of the human brain with its complex environment" (p. 477). That argument frightens me, but I have a difficult time formulating a clear and developed argument to support the notion that my selfhood is somehow more than purely a mechanistic, biological system. If I find any solace in this book concerning my own consciousness, it is Kurzweil's belief that "If I ask the question, 'does a particular entity emit carbon dioxide,' I can answer that question through clear objective measurement. If I ask the question, 'is this entity conscious,' I may be able to provide inferential arguments—possibly strong and convincing ones—but not clear objective measurement" (pp. 468-69). Instead, he concludes, consciousness is a philosophical question rather than a scientific one.

In one of George Herriman's Krazy Kat strips (a syndicated newspaper comic from the 1920s-50s), *Krazy Kat* shoos his friend Ignatz Mouse away saying, "I witch to be alone wit' my tott" to which Ignatz replies, "Alone with your thought—how silly… how can you be alone if you have a thought with you" (Herriman, Contents page). The final image is of a disembodied thought floating like a dust devil down a deserted street and out into the desert. At the time, this must have seemed like silly metaphysical antics on the part of Herriman, but in light of Kurzweil's *Singularity*, it is strikingly prophetic of a sea of thoughts in the form of dispersed and uncontrollable information, disconnected from authors or specifically identified readers. This represents a serious challenge to human autonomy. According to Kurzweil, it will be possible for the individual identity to be uploaded to the mesh. We will still have bodies, but they will be of our own choosing, largely consisting of nanoparticles (referred to as foglets) that can combine and recombine in any number

of ways (p. 310). Alternately, we might leave the physical plane altogether, replacing it with a virtual reality that is more elastic, safer and better suited to our many needs. Of course, these complex technologies will still be controlled by those who know (technologists) and consumed largely by those who don't.

Furthermore, Kurzweil suggests that it will be difficult to maintain clear ownership of information, that all experiences will be communicable via "beams" so that any person can experience exactly my own experiences (we will be able to, literally, walk a mile in someone else's shoes). Marriage, in this future, is now a complete merging of the brains and "bodies" of two people. "Just wait," Kurzweil explains to Molly 2004 in one of those dialogues, "until we're predominantly nonbiological. Then we'll be able to merge our thoughts and thinking at will, so finding boundaries [of selfhood] will be even more difficult."
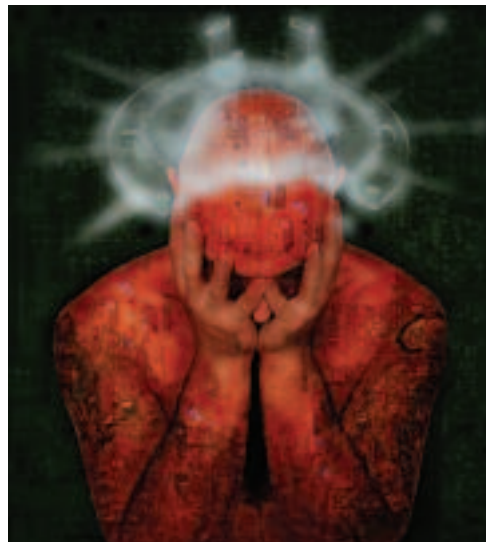
Even here, in the *Democratic* United States, the pressures exerted on individuals to participate in groupthink can be powerful. Psychologist Irving L. Janis does a fine job of exploring the groupthink concept at work in American politics in the seminal work of that name. Perhaps the tightly interwoven and integrated knitting of that world wide "mesh" (as Kurzweil calls the future WWW) will be offset by the vast wealth of information that it consumes. A test run of this power play can be seen through deliberate stud-

ies of the open source "wiki" environments of today, where information is dynamic and editable by any reader. Do we find, in those entries, a trend toward dissensus or consensus? In their 2005 study entitled *Collaborative Authoring on the Web: A Genre Analysis of Online Encyclopedias*, William Emigh and Susan C. Herring of Indiana University arrive at a disheartening conclusion: "Ironically, 'good' rank-and-file users on Wikipedia achieve in near-absolute terms what some participants in Everything2 fear from self-interested administrators, but which Everything2 comes nowhere close to realizing: imposition of stylistic homogeneity. While this could be viewed as an accomplishment—Wikipedia is increasingly being consulted as a standard reference, in part due to its resemblance to traditional print encyclopedias—it is at odds with the goal of the wiki (and user-created content) movement to create content incorporating diverse perspectives, and more generally to foster new and better communication practices" (pp. 9-10, http://csdl2.computer.org/comp/proceedings/hicss/2005/2268/04/22680099a.pdf).

Throughout this book there is a seemingly intentional, and certainly meaningful, confusion of scientific speculation with religious prophecy. Kurzweil explains that

> Evolution moves toward greater complexity, greater intelligence, greater beauty, greater creativity, and greater levels of subtle attributes such as love. In every monotheistic tradition God is likewise described as all of these qualities, only without any limitation: infinite knowledge, infinite intelligence, infinite beauty, infinite creativity, infinite love, and so on… We can regard, therefore, the freeing of our thinking from the severe limitations of its biological form to be an essentially spiritual undertaking (p. 391).

There are also subtler moves, such as the repeated use of words such as "transcendence" and "awakening," as well as the description of intelligence as "the destiny

of the universe" (p. 361), that further contribute to this confusion. Kurzweil would likely recommend that this is largely because evolution has brought us to the point where we can create tools/machines that enable us to more completely explore (or negotiate) the

In just the past year, the social networking software has become increasingly complex and ubiquitous.

most profound human questions—a realm of inquiry that has traditionally belonged to the religious community. Regardless, this is one particular altar that many find themselves submitting to—we increasingly conduct research in online forums (including wikis), we carry our cell phones everywhere we go, some of us even tapping into social networks like dodgeball.com in order to more visibly connect to the social grid. We maintain blogs and participate in online forums, all of which are archived and might potentially be tagged (a more sensitive form of the hyperlink) for wide distribution in a World Wide Mesh.

In just the past year, the social networking software has become increasingly complex and ubiquitous. A new website, www.plazes.com, allows you to bridge the virtual and physical worlds by assigning addresses, descriptions and comments to physical spaces, a process that Jon Udell has called "annotating the planet." Our PDAs grow smaller and more powerful, large parts of our memories are stored on flat silicon chips, and according to one of the designers of Second Life (an online virtual reality program) who attended the Accelerating Change Conference in 2005, one virtual real estate broker in the virtual world is making triple digit income (using real US currency) selling virtual space to other virtual users.

My experience with Sears' artificially intelligent automated voice recognition program hardly constitutes the emer-

gence of Strong AI, or a profound shift in technological development and the human experience, but it does represent a significant step toward the diffuse and flexible systems model of the brain and a step away from the logic-tree-based functioning of supercomputers like Deep Blue and the Windows operating system. Even if Ray Kurzweil is only half right (and his track record around prophecy suggests that's a low estimation), then this book is a worthwhile read even if it only functions as a roadmap for navigating the future world or worlds. More importantly, the ideas the book contains are challenging on a foundational human level—you will not escape this book without worrying some new knots into the old philosophical questions of human identity and spiritual existence.

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Biography

Matthew Jolly teaches English Composition, Creative Writing and Literature at the University of Advancing Technology. He holds a Master of Fine Arts degree in Creative Writing from ASU. He's not sure that he loves the Arizona weather, but he is happy to have found his wife, Lauren, in that state. They live together in a strange place called Ahwatukee. His work has also appeared in *The Tributary; Phoebe: A Journal of Literature and Art; The New Delta Review;* and *Hayden's Ferry Review.* His review of Edward de Bono's literature on thinking was featured in the previous issue of the *JAT.*

Letter to a Young Game Programmer

by Jonathan Harbour
University of Advancing Technology

The best way to get a job as a programmer is to know someone who already works for a company, someone who knows of specific openings.

This article is a no-nonsense and direct challenge to the aspiring game programmer to take his or her work seriously… right now.

What is your ultimate goal? If it is to be a professional game programmer for a big-name publisher, that's a good goal, but you need to pursue that goal in the right way and keep your expectations at a realistic level. The most important factors to consider for this field are motivation, attitude and expectations.

The best way to get a job as a programmer is to know someone who already works for a company, someone who knows of specific openings—and who has buddies at other companies on other projects. And the best way to get to know game developers is to write your own games with a very distinct style of your own and cover niche subjects—you might be surprised when a famous game developer sends you an email to compliment you on a casual game! You don't necessarily want to approach just members of management at a game company. You always want to network with people on the inside. I once recommended a friend for a job at a game company, and I didn't even work there! I just happened to be acquainted with one of the artists who knew of an entry-level programming position.