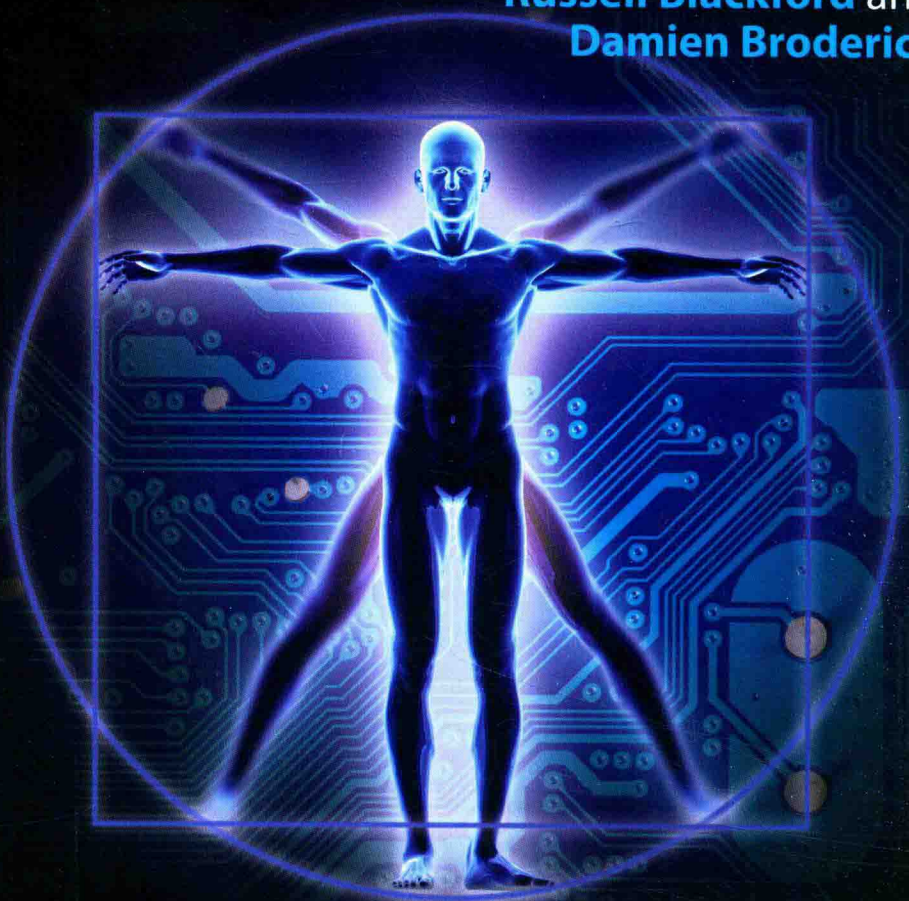
Intelligence Unbound

The Future of Uploaded and Machine Minds

Edited by

Russell Blackford and
Damien Broderick



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Intelligence Unbound

To Aubrey Townsend, who handed me the tools
Russell Blackford

To R. Daneel Olivaw, Golem XIV, Donovan's Brain, and Paul Durham, in the hope that things turn out better next time
Damien Broderick

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Damien Broderick

1 Machine minds or humans copied into machines?

In an immensely confident but typical summary of the neurocomputational model of mind now dominant in science, Nobel Laureate Eric Kandel wrote in 2013:

> This new science of mind is based on the principle that our mind and our brain are inseparable. The brain is a complex biological organ possessing immense computational capability: it constructs our sensory experience, regulates our thoughts and emotions, and controls our actions. It is responsible not only for relatively simple motor behaviors like running and eating, but also for complex acts that we consider quintessentially human, like thinking, speaking and creating works of art. Looked at from this perspective, our mind is a set of operations carried out by our brain.[1]

More than two decades earlier, the science fiction writer Charles Platt offered a somewhat ampler view:

> A person's mind is structure as well as content. Without the structure, the content can't function. Our minds have to have the specialized architecture ... in which to operate. We can store our brain data elsewhere, but when we do that, it's as nonfunctional as a videodisc without a disc player. (Platt 1991: 238)

In the next 25 to 100 years, genuinely intelligent machines are likely to be developed up to and beyond the highest levels of human ability.

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We're not there yet, in part because the raw computational power of the brain hugely outstrips even the fastest computer. In mid-2013, the world's top supercomputer was the Tianhe-2, holding more than a million gigabytes of memory and running at some 50 petaflops (where a petaflop is a thousand trillion calculations per second) on its best days. Using an only slightly less extraordinary machine, Japan's 10 petaflop K supercomputer, scientists simulated 1 percent of 1 second of human brain activity. That took 40 minutes of screamingly fast calculations.[2]

You would need to multiply that by a factor of a quarter million to emulate a brain. Luckily, Moore's law (roughly: "computer power doubles every year and a half"[3]) suggests that a machine of this majestic status will be available – all things going well – in perhaps 30 more years. And of course in the meantime, scientists might learn better ways to get the job done sooner on leaner computers.

> Markus Diesmann of the Institute of Neuroscience and Medicine at Germany's Forschungszentrum Julich believes that, within the next decade, we'll be able to use exascale computers – capable of 1000 times one quadrillion operations per second – to represent the entire [*sic*] of the brain "at the level of the individual nerve cell and its synapses."[4]

And Henry Markram, a professor of neuroscience at the Swiss Federal Institute for Technology and founder and director of the Blue Brain Project, is coordinating the Human Brain Project (Keats 2013). This 10-year, €1.3 billion flagship project, selected in January 2013 by the European Commission, plans to simulate

> a rat cortical column. This neuronal network, the size of a pinhead, recurs repeatedly in the cortex. A rat's brain has about 100,000 columns of [about] 10,000 neurons each. [A] human cortex may have as many as two million columns, each having [about] 100,000 neurons each ... These models will be basic building blocks for larger scale models leading towards a complete virtual brain.[5]

Will they necessarily be conscious, such brainy machines? Perhaps not, or at any rate not as we experience consciousness. The speeding locomotive, or "Iron Horse," never resembled a real horse, yet it carried a heavier load and moved much more swiftly and without tiring. A submarine isn't much like a whale, yet dives deeper and travels faster. Birds sing more beautifully than jet planes or rockets, but their capacity to fly high, far, and rapidly was outstripped by machines a century ago. Chess programs defeat grand masters without being self-aware, and IBM's Watson supercomputer beat top human contestants on *Jeopardy!*, winning a million dollars but without a jitter of anxiety or a shout of joyful pride.

Even so, machine or artificial intelligence (AI), unlike ours, might well have the ability to understand, modify, and improve its own source code, carrying it by great leaps into domains of ability that unaided flesh can never hope to reach. Half a century ago, the mathematician I.J. Good proposed that an "ultraintelligent machine" could design ever more enhanced versions of itself, resulting in an "intelligence explosion" that would leave humans far behind (Good 1965). If such supersmart computers also achieve consciousness, we (or our children and grandchildren) shall share the planet with a new and intriguing species of mentality.

But wait – what *is* intelligence? Thousands of learned books and scientific or philosophical papers have probed every corner of this apparently simple question with no clear consensus emerging. We can start with theoretical neurophysiologist William Calvin's breezy summary in *How Brains Think*:

> I think of intelligence as the high-end scenery of neuro-physiology – the outcome of many aspects of an individual's brain organization which bear on doing something one has never done before ... some of *what* intelligence encompasses are cleverness, foresight, speed, creativity, and how many things you can juggle at once. (1997: 11)

Instead of our brutally slow chemical neurotransmitters, ionic currents, and neural designs, built by millions of years of ad hoc evolution, AI will use engineered electronic or photonic neural nets operating a million times faster. Instead of memories limited by the gene-architected size of our skulls and the human birth canal, AIs will possess effectively limitless storage constrained only by pathways traversed at the speed of light. In that sense, the arrival of advanced AIs will mark the end of some of the limitations that bind human intelligence. Intelligent and superintelligent machines will truly represent "intelligence unbound."

If and when this happens, humanity will face ethical issues of unprecedented gravity and difficulty. What obligations do we owe to artificial minds? Can they morally be switched off, like any other instrument or mechanical device? Or do they share human rights to life and the pursuit of happiness, the right of due process? Is there any way in which their designers can defang hazardous AIs that might turn on us, can make them compliant, obedient to their creators? Or is that slavery, mind bondage? If they are our intellectual superiors, can they at least be encouraged to adopt an attitude of benevolence toward us? Is it even technically possible to enforce friendship between protein and silicon beings, once the AIs pass beyond human comprehension in their abilities and potential?

In addition to this vexed and giddy outlook, in a near future of such fabulous machines, it will be possible to blend human and machine by enhancing

our current bodies with chips, modules, and interface devices (a process of "cyborgization" that has already begun).

All these prospects, and more, are discussed in detail in the chapters of this book. No single viewpoint is privileged throughout; these topics remain genuinely controversial, even philosophically troubling, so it is necessary to approach the topics carefully, exploring the pros and cons. And if the imminent arrival of machines with intelligence, however alien, is sure to throw our world into confusion and tumult, how much more will the possibility of minds copied from organic brains to inorganic machines? Not just copied as a static representation, as the Mona Lisa might be counterfeited with great fidelity by a skilled artist, but imbued with emotion, awareness, and all the other aspects of personhood.

2 Emulating the mind

This radical option might become available alongside the emergence of machines powerful enough and intricately connected enough to house a true mind. In the process – called "uploading" by some and, confusingly, "downloading" by others, and "whole brain emulation" by a third group – we could *become* machines while remaining ourselves, physically transferring the structure of our minds into capacious computer programs that generate thought and the quality of minds when they are run. Uploads would live in vivid virtual realities fitted to the needs of their simulated minds, while remaining in touch with the external world.

Is this a crypto-religious hope, the much-lampooned "Rapture of the Nerds"? It does echo religious hopes of reincarnation widespread in Asian cultures, where a non-material essence slips out of an injured or aged body to enter the waiting vessel of an unborn infant. But no, the prospect of uploading has nothing significantly in common with those ancient wishful, consoling dogmas. Naturalistic materialism, the current scientific paradigm, maintains that mind is nothing other than the sublimely complex workings of the physical brain and its bodily extensions in a world of particles and force fields. If that is what we *are*, nothing prevents us from copying – mapping – our neurological complexity into some more durable, swifter material substrate.

Still, isn't this a version of the cliché from bad horror movies: a naked brain in a vat of chemical soup? Some will complain that uploading is a nightmare proposed by body-hating, frightened computer hackers, those nerdish social incompetents allegedly fleeing from sensuous reality and human warmth.

It is true that many proponents of uploading dislike the limitations and messy urgings of the body and its ancient, now often maladaptive Darwinian drives. For others, as Max More details in his chapter, what drives the interest in uploading is a desire for more life, for the greatest possible access to this beautiful and complex universe. It can't be explained away as simple hatred or fear of the flesh.

Suppose it is true that mind and passion and soul are indeed the body at work, a whirling composite of matter and force and energy, engaged with the world. As we eat, drink, and excrete, the very atoms in our cells are regularly replaced. Should we object if mind changes its location from one kind of organized and ceaselessly replaced matter to another material substrate?

It is easy to become trapped by old preconceptions. Is the mind really a machine? If being a machine suggests clockwork or even the relatively stupid computers in our smart phones (already 50 percent more powerful than the greatest supercomputers in 1976), of course not. Even these limited computers are vastly more complex than an eighteenth-century wind-up parrot, or a nineteenth-century piano driven by a paper tape. The human brain is not like a broken-down motor-mower, and nobody ever thought it was.

Uploading need not imply a world of bloated grubs lying in the dark with their brains wired to spreadsheets and simulated worlds. On the contrary: transhumanist philosopher Max More, who intends to upload when that becomes an option (and use his new freedom to explore the stars), put his own case back in the 1990s: "I'm in the gym five days a week, plus I either run or cycle. I can boast that I do 710 lbs on the leg press. No atrophied body here!" In 2013, he added with amusement, "That was 710 lbs for 8 repetitions. I'm currently doing 720 lbs for 15 reps, so I'm definitely stronger. For 8 reps, I can do something over 800 lbs" (private communication). The initial goal of uploaders would be to emulate and enhance the brain, and that requires rich connections to external reality. It calls for give and take, building from the peculiar truth that inside our porridge-like brain matter is where our selves are generated. That fact does not repudiate the body, far from it.

A quadriplegic with no access to the world other than her mouth and ears and eyes and her vivid, courageous brain *is a person*. By contrast, the superb corpse of an Olympic athlete or concert pianist with a fatal brain injury, its metabolism sustained by medical machines, is no kind of person at all, just a tragic reminder of the fallibility of life and a storehouse for luckier transplant patients.

It's worth noting that if synthetic neurons can be made half the size of the organic varieties, replacing each brain cell after copying its structure