Chapter 7

The Last Natural Brain

The human brain had vast memory storage. It made us curious and very creative. Those were the characteristics that gave us an advantage - curiosity, creativity and memory. And that brain did something very special. It invented an idea called ‘the future.’ ~ David Suzuki

The work of the brain would be easy if we knew what we needed to remember or understand in the future. Life is full of surprises – new people whom we need to know, names we have to remember, problems we try to solve.

To a creationist, the brain as God’s masterpiece seems self-evident: a summation of motor synapses and sensory stimuli, infused with the most important emotions of all – faith, hope and love; the least copy-able of God’s own artworks. To a computer-programmer, this vision may seem a gimmick, a concept that has the blitheness of ignorance.

In an interview published in The Guardian, the celebrated scientist Stephen Hawking said:

I regard the brain as a computer which will stop working when its components fail. There is no heaven or afterlife for broken down computers; that is a fairy story for people afraid of the dark.

The idea that the brain, once its blood supply has ceased, simply degenerates into nothingness is both stirring and frightening. For human beings

1 http://www.brainyquote.com/quotes/authors/d/david_suzuki.html#M5YPjueO2ZAgwfe.99 accessed Dec 25, 2015.
2 Ian Sample, Science Correspondent. The Guardian. 15 May 2011. Stephen Hawking: ‘There is no heaven; it’s a fairy story’ http://www.theguardian.com/science/2011/may/15/stephen-hawking-interview-there-is-no-heaven accessed Dec 25, 2015.
drunk with an engorged quest for immortality, the search for a ‘human computer’ to replace or replicate our brain is ongoing. But is it possible?

About two decades ago, in 1994, Penrose wrote³:

As yet, no computer-controlled robot could begin to compete with even a young child in performing some of the simplest of everyday activities: such as recognizing that a colored crayon lying on the floor at the other end of the room is what is needed to complete a drawing, walking across to collect that crayon, and then putting it to use. For that matter, even the capabilities of an ant, in performing its everyday activities, would far surpass what can be achieved by the most sophisticated of today’s computer control systems.

Scenes from films like ‘Blade Runner’ and ‘Terminator’ featured intelligent bioengineered ‘replicants’ whose brains are indistinguishable from human thought, but academics have been long frustrated by the inability to replicate a human brain’s analytical power.

I met Garry Kasparov, considered one of the greatest chess grandmasters at an international ideas conference called THiNK, when we were both asked to sign copies of our books at the store they had set up for speakers’ books — Garry was signing copies of How Life Imitates Chess: Insights into life as a game of strategy⁴ and I was autographing copies of my Skin: A Biography⁵. That was the biggest book-signing I’ve ever had to do — 250 copies one after the other.

‘You like chess?’ I was lured out of the monotony by Garry’s voice. He had been leafing through my book and found a passage featuring Bobby Fischer, the late chess prodigy.

Bobby Fischer, towards the end of his life, became reclusive, neurotic, paranoid and ‘stateless’, and Iceland had offered him residence after the US refused to allow him entry post a trip to Japan. In his prime, Fischer had been obsessive about chess and had admired Marcel Duchamp, a French artist, who gave up art for chess. Duchamp had described an opening called trebuchet or ‘the trap’. But his favourite chess position was of an endgame called the Lasker–Reichelm position: a rare and unique position where black cannot win, but at best delay events.

‘My dad used to play tournaments,’ I replied. ‘I played as a child with him, but not later on.’

³ R. Penrose. Shadows of the Mind. Oxford: Oxford University Press. 1994 page 45.
⁴ Garry Kasparov with Mig Greengard, How Life Imitates Chess: Insights into life as a game of strategy (Arrow Books, UK, 2008).
⁵ Sharad P. Paul. Skin: A Biography (4th Estate, 2013), p. 78.
In his prime as World Chess Champion, Kasparov had famously played against an IBM supercomputer, named ‘Deep Blue’. A team of computer and chess experts recalibrated the machine between games, while Kasparov reprogrammed his own brain. The first match was played in February 1996 in Philadelphia, Pennsylvania. Kasparov won 4–2, losing one game, drawing in two, and winning three. A rematch took place in 1997, with Deep Blue winning 3½–2½. I asked Garry about what it was like to play a computer at chess — surely a computer was capable of calculating possible moves faster than a human?

‘The best way to beat a computer is to play unlike a computer,’ Gary said. ‘Which is why Carlsen will win this year’s chess championship . . . and why Fischer was so good.’ I opened Garry’s book and read: “… ordered systems lose less energy than chaotic systems.” If our pieces work together they can better transform one advantage into another without losing quality. This theory of ‘ordered systems’ conserving energy and ‘pieces working together’ to create an advantage is a good analogy to explain the functioning of the human brain and memory.

One of the problems thus far has been that in medicine, we have simplified the brain into modules – physicians have insisted in dividing up the brain into well-defined anatomical regions – frontal lobe for personality, temporal lobe for memory etc., theories that we know are problematic when we survey the evidence. Just because computers need memory, it seems convenient to locate a ‘memory module’ in the brain. Megan Erickson puts it elegantly:

The brain is not a storage dump, and consciousness is not a place. Synapses are also far more complex than electrical circuits. Neither processing speed nor short term memory capacity are fixed, whereas RAM is.

We measure computers based on storage and speed, yet even an average human brain shades a computer when it comes to efficiency. Writing in the Scientific American, Mark Fischetti notes:

The world’s most powerful supercomputer, the K from Fujitsu, computes four times faster and holds 10 times as much data. And of course, many more bits are coursing through the Internet at any moment. Yet the Internet’s servers worldwide would fill a small city, and the K sucks up enough electricity to power 10,000 homes. The incredibly efficient brain consumes less juice than

\[^{6}\text{Megan Erickson. “The Electronic Brain? Your Mind Vs. a Computer.” http://bigthink.com/re-envision-toyota-blog/the-electronic-brain-your-mind-vs-a-computer accessed Dec 25, 2015.}\]

\[^{7}\text{Mark Fischetti. Scientific American. Nov 1, 2011. “Computers versus Brains.”}\]
a dim lightbulb and fits nicely inside our head. Biology does a lot with a little: the human genome, which grows our body and directs us through years of complex life, requires less data than a laptop operating system. Even a cat’s brain smokes the newest iPad—1,000 times more data storage and a million times quicker to act on it.

How does the ancient brain beat the power of modern computers? It is the battle of the analog vs. digital – humans brain store information as varying threads and ‘learn’ and evolve based on previous experiences; a computer by contrast sees memory as a binary collection of ones and zeroes. Scientists working in this space of artificial intelligence now realize that storing memory as varying threads of information, rather than as binary digits is the key to making computers ‘more human.’

Memory is everything when we choose a computer, yet the capacity to remember is the least important in selecting a mate as a human companion. When we go to the computer store, devices tout memories of 4GB or 16GB of RAM (Random Access Memory). RAM may help a computer multi-task but any arrest in the power supply leads to a rapid unraveling of memory (at least until the last ‘auto-save’!). Enter memory-resistors, or ‘memristors’ – electronic components where electrical resistance is not constant as in standard resistors, but is determined by the history of the electric current that has previously flowed through it. In other words, a memristor “remembers” like a human brain. Researchers working at the Royal Melbourne Institute of Technology (RMIT) and the University of California in Santa Barbara claim to have constructed the world’s first electronic memory cell that effectively mimics the analog process of the human brain – and with it comes the possibility and peril of a truly bionic brain. However, there exist some significant hurdles – when it comes to memory, speed alone isn’t the problem – artificial intelligence (AI) will need to come up with new ways to match the 2C’s of brain function – complexity and consciousness.

Perhaps medical neuroscience has been slow to move towards ‘singularity’ due to the constraints of a medical model, or the differences between biological and technological concepts of the brain. For a start, if the human brain could be re-created, then medicine would have to be more inclusive, and couldn’t inflict the prices it does on the premise of citizenship of a guild or cartel. The world of computer science is inherently less bureaucratic by nature, but also it couldn’t care less about things like difficulty or danger that an artificially intelligent world would bring.

The concept of Singularity was first espoused by Vernon Vinge, from the Department of Mathematical Sciences of San Diego State University, to mean ‘the imminent creation by technology of entities with greater than
human intelligence.’ Somewhat chillingly (for natural humans), in this essay written in 1993, Vinge wrote⁸:

Within thirty years, we will have the technological means to create superhuman intelligence. Shortly after the human era will have ended.

However, people like Ray Kurzweil, proponents of ‘singularity’ theorize that computers shall exceed human capacity for thought fairly soon. In his book, The Singularity Is Near: When Humans Transcend Biology (Viking Press, 2005) Kurzweil creates a vision of intelligent nano-robots integrated into our bodies, our brains, and our environment, with a capability to eradicate pollution and poverty, offering the new artificial man extended longevity, while enjoying the sensory stimulation of a full-immersion virtual reality (think movies like “The Matrix” or “Being John Malkovich”). Kurzweil sets the date for this dramatic and disruptive transformation into a new human species as 2045, a hundred years after the end of the Second World War – during that year, the non-biological intelligence created will be one billion times more powerful than all human intelligence today.

Indeed, the world of nanotechnology is progressing rapidly. Microscopic robots can be placed inside human organs to give us an inside-knowledge of both brains and blood vessels. In his book, Kurzweil feels that for Singularity to occur, there has to be a confluence of three scientific streams – the three great overlapping technological revolutions that go by the letters “GNR,” that stands for genetics, nanotechnology, and robotics. Genetic sequencing has also become faster and cheaper – sequencing the HIV virus took over a decade; recently SARS virus was sequenced in a month. This is about the last natural man playing God – creating a new species in man’s own image, using the power of science with one difference from the last time around – the new bionic humans will no longer be in the shadow of their creators. Kurzweil does not see hardware requirements as a barrier. In fact, in an interview⁹ about his book on Singularity¹⁰, Kurzweil describes the computing power of the brain and computers thus:

We can break this down further into hardware and software requirements. In the book, I show how we need about 10 quadrillion (10¹⁶) calculations per second (cps) to provide a functional equivalent to all the regions of the brain. Some

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⁸ Vernon Vinge. “The Coming Technological Singularity: How to Survive in the Post-Human Era.” Proceedings of a symposium cosponsored by the NASA Lewis Research Center and the Ohio Aerospace Institute; held in Westlake, Ohio, March 30-31, 1993.

⁹ Questions & Answers. Ray Kurzweil. The Singularity Is Near: When Humans Transcend Biology. Viking Press. USA. 2005. http://www.singularity.com/qanda.html accessed Dec 25, 2015.

¹⁰ Ray Kurzweil. The Singularity Is Near: When Humans Transcend Biology. Viking Press. USA. 2005.
estimates are lower than this by a factor of 100. Supercomputers are already at 100 trillion (10^{14}) cps, and will hit 10^{16} cps around the end of this decade. Several supercomputers with 1 quadrillion cps are already on the drawing board, with two Japanese efforts targeting 10 quadrillion cps around the end of the decade. By 2020, 10 quadrillion cps will be available for around $1,000.

There is not much dissent about the concept of Singularity anymore; the controversies are more focused on the actual algorithms. Speaking of algorithms, it is this ability of computer-scientists to view the human brain as a generator of various algorithms that creates the possibility of treatment of various disabilities.

At THiNK, I also met Moran Cerf, my good friend, who is now a Professor of neuroscience and business at the Kellogg School of Management and heads the neuroscience program at Northwestern University. Additionally, he holds a position at the department of neurosurgery, where he studies patients undergoing brain-surgery to examine behavior, emotion and decision-making. Moran sees the brain differently to me. I trained in medicine and have an interest in evolutionary biology and cutaneous oncology. Moran had a background as a computer hacker, before he studied neuroscience, and sees the brain as a generator of patterns – all emotions or dreams or maladies can be interpreted by studying brainwaves – once you’ve studied enough patterns, the ‘big data’ seems to make sense – for example, as we discussed the ability to mimic a human brain, Moran spoke to me about the interpretation of dreams. Using electrodes implanted in the brain he was able to decipher dreams – he could for example tell if you were thinking of an elephant (at the time we spoke, the technology was not refined to determine if the elephant was African or Asiatic).

In his lecture, Moran spoke about an experiment that featured a Chimpanzee and a robotic arm. The scientists implanted electrodes onto the motor cortex, over an anatomical region known to signal arm and hand movements. These electrodes, each connected to neurons that were wired to the brain, were also linked to a computer. There were plenty of food treats in the rooms – grapes, bananas etc. It didn’t take a lot of time before the ape realized that the robotic arm was able to read brain signals, and therefore could be controlled by thought. Within a few days, the monkeys needed no help. They sat stationary in a chair, repeatedly manipulating the arm with their brains to reach out and grab grapes or nuggets of food dangled in front of them. Imagine the useful of thought-control for physically-disabled patients.

Writing about a similar experiment in *Nature*\(^\text{11}\), Dr. John F. Kalaska, a neuroscientist at the University of Montreal, feels that as this technique is

\(^{11}\) John Kalaska. Neuroscience: Brain control of a helping hand. *Nature* 453, pages 994-995 (19 June 2008).
refined further, scientists might even discover areas of the cortex that allow more intimate, subtle control of prosthetic devices:

Such controllers would allow patients with severe motor deficits to interact and communicate with the world not only by the moment-to-moment control of the motion of robotic devices, but also in a more natural and intuitive manner that reflects their overall goals, needs and preferences. For example someone paralyzed or in an institution because of mobility issues could order a robot to provide food or coffee by using thought-waves. The technology is here. Now.

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In the past, Drosophila, the fruit fly, was the most studied ‘model organism’ in genetics and biology. This was because it is hardy, easy to care for, breeds quickly and lays many eggs. In 1965, Sydney Brenner, mooted Caenorhabditis elegans, the non-parasitic nematode worm, as a new model organism for studying organ development, cell death, behavior and many other biologic processes. Brenner had obtained a culture of the Bristol strain of this worm from Ellsworth C. Dougherty (then in the Department of Nutritional Sciences at the University of California at Berkeley), who had worked extensively with the organism. Brenner, originally from South Africa and then director of the Laboratory of Molecular Biology (LMB) at Cambridge had written: “nearly all the ‘classical’ problems of molecular biology have either been solved or will be solved in the next decade.” For his work on this worm, in 2002, the Nobel Prize committee honored Sydney Brenner with the Nobel Prize for Physiology or Medicine (along with John Sulston and Robert Horvitz). This soil worm had excited scientists as it had many attributes that made it a natural model for scientific study – for a start, it is barely over 1 mm in length, lives for approximately three days, feeds on easily cultivated bacteria such as E. coli and a single Petri-dish can hold over 10,000 of these critters. In its hermaphrodite form, it is even capable of reproducing itself. It is anatomically simple, with a body containing just over 1000 cells including a 302-cell nervous system.

C. elegans was the first multicellular organism to have its genome completely sequenced. The genome of this worm contains 97 million base pairs. This is about 3% the size of the human genome, which has three billion base pairs.

Drawing a connectome is basically mapping all neural connections in the brain, and can be thought of as being similar to an electrical “wiring diagram”. In 1986, the entire connectome of C. elegans was mapped, and as the genome had been mapped, science was much closer to completing the GNR triad needed to create an artificial brain. Therefore in 2011, a team of scientists from the US, Europe and Russia began the OpenWorm Project –
an attempt to build a complete artificial nervous system of this worm with the capacity to stimulate various actions i.e. an artificial *C. elegans*.

Researchers on the OpenWorm Project soon reached a philosophical crossroad. If they could replicate the nervous system of this creature and implant that ‘brain’ into another body, would that body behave like a worm? This was the very experiment they undertook – scientists took the connectome of a *C. elegans* worm and transplanted it as software into a Lego Mindstorms EV3 robot – what happened next? The Lego model robot began to behave exactly like the worm! Stimulation of the nose stopped forward motion. Touching the anterior and posterior touch sensors made the robot move forward and back accordingly. Stimulating the food sensor made the robot move forward. They now had a creature that behaved like a worm but was a Lego model (and therefore not as squishy). Slowly but surely science is wiggling towards Singularity.

It’s all very well messing about with a tiny nervous system, but if we were to build a truly human brain, could we control this being? After all human beings have 13 billion neurons with trillions of possible interactions. Many scientists indeed voice a fear of artificial intelligence taking over the world. The other possibility for an artificial brain is both frightening and exciting. Think about this: If the OpenWorm Project could be replicated, we would no longer be constrained by our organic bodies – physical forms that were the result of four billion years of evolution by natural selection. Life could become inorganic, powered by exact replicas of our own brains. This possibility was made more probable by funding from the European Union – in April 2013, it selected the Human Brain Project to be its scientific flagship, giving it a grant of more than €1 billion.

Even before the OpenWorm Project model, Henry Markram, a South African neuroscientist led the Blue Brain Project at the École Polytechnique Fédérale de Lausanne in Switzerland. Using a similar technique (as in the *C. elegans* research), his team began studying the neural networks of rat brains – with a goal of computer-based models that mirror the rat brain’s complex biological networks. “Technologically, in terms of computers and techniques to acquire data, it will be possible to build a model of the human brain within 10 years,” Markram has been quoted saying.¹²

Yuval Harari, debates the transition or rather our progress as a species from evolution by Natural Selection to evolution by Intelligent Design. He calls this ‘the greatest revolution in thousands of years of history, but also the greatest revolution in billions of years of biology.’ Harari, in *Sapiens: A

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¹² Max Miller. Can Computers Be Conscious? Big Think. http://bigthink.com/going-mental/can-computers-be-conscious accessed Dec 25, 2015.
*Brief History of Humankind* writes about the many positive aspects of intelligent design\(^\text{13}\):

The replacement of natural selection by intelligent design could happen in any of three ways. The first way is through biological engineering. Bio-designers could re-engineer the shapes, abilities and desires of organisms, in order to realize some preconceived cultural idea. There is nothing new about biological engineering, per se. People have been using selective breeding, castration and other forms of bio-engineering for at least 10,000 years. But recent advances in our understanding of how organisms work, down to the cellular and genetic levels, have opened up previously unimaginable possibilities. For example, scientists can today take a gene from a jellyfish that glows in a green florescent light, and implant it in a rabbit or a monkey, which starts glowing in a green florescent light. E. coli bacteria have been genetically engineered to produce human insulin and bio-fuel. A gene extracted from an arctic fish has been inserted into potatoes, making the plants more frost resistant.

Harari has a very hopeful view of intelligent design. But as a medical doctor, I am aware that medicine is often unpredictable, phenomena like the ‘placebo effect’ cannot be easily explained by computers. A computer can beat me hands down in predicting what percentage of my patients would respond to a particular medication, but could it deal with the imperfections and frailties of the human mind?

Max Pemberton, the author of *The Doctor Will See You Now* (Hodder and Stoughton, 2012) writes about an experiment conducted by the psychologist Ellen Langer in 1979\(^\text{14}\). A group of elderly men were taken to a ‘reminiscence retreat’ outside Boston. The first group was the ‘control group’ and spent a week simply reminiscing about the Fifties. The second group, however, was taken back in time and surrounded by objects from the Fifties and asked to behave as if it really was 1959. Over the week, something astonishing happened. The men stopped using their walking sticks, they began to walk faster and their posture improved. What this experiment demonstrated is that as humans we are more than genes and brains. We have a collective consciousness. Pemberton is skeptical that computer code could replace medicine. “Computers are a useful tool in treatment, but medicine is far too complex to be reduced to code,” he says\(^\text{14}\). Like me, Pemberton is a medical doctor and this may only turn out to be wishful thinking.

\(^{13}\) Yuval Noah Harari. ‘Sapiens: A Brief History of Humankind.’ Chapter 20. Harper; 1St Edition (February 10, 2015).

\(^{14}\) Max Pemberton. A computer can’t compute the power of the human mind. The Telegraph. 29 April, 2013.
Technically it will soon be possible to create artificial versions of our brains and implant them into all kinds of inorganic models. Given a choice, you could take on any form that you wish. The question more to the point would be: What do you want to become? But with your brain and without your existing form, would that really be you?

When I visit Oxford University, I usually stay at Keble College. It is a lovely college and the last time I was there, I stayed in the Lewis Room, named after C.S Lewis. In 1945, Lewis penned That Hideous Strength: A Modern Fairy-Tale for Grown-Ups\(^{15}\), as the final book in his theological sci-fi Space Trilogy, which was recently reviewed in Salvo magazine\(^{16}\). In its plot, a philosophy professor, Mark Studdock, gets caught up in a diabolical scheme to take over the world. The leader of the cult is the severed head of a criminal genius, kept alive by tubes and wires. “Don’t you see,” says one character, inviting Mark into the fellowship, “that we are offering you the unspeakable glory of being present at the creation of God Almighty?” This book was Lewis’ foray into Transhumanism – Transhumanists speculate freely about becoming immortal by “uploading” their consciousness into computer brains with robotic bodies, something that is now becoming closer and closer to scientific reality.

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In my view, there are two requirements for a brain to be truly human: the 2C’s of complexity and consciousness.

The complexity of the human brain has been a barrier in facilitating rapid evolution. Chimpanzees, the apes closest to humans weigh about 20% less than the average human, but the human brain is 250% larger than that of a chimp. Given this, it was assumed that human genes that regulate brain development would evolve at a much faster rate than that of apes. In actual fact, the reverse is true. This is all to do with complexity.

You see in primitive creatures, the larger the brain, the more rapid the evolution – protein sequences in chimpanzees changed faster than genes from monkeys, which changed faster than those from mice. Writing in the influential scientific journal PLOS Biology, a team from the University of Chicago found that gene evolution in human beings has slowed. They noted\(^{17}\):

\(^{15}\) C.S. Lewis. That Hideous Strength (Space Trilogy, Book 3) 1945 Scribner; Reprint edition (May 13, 2003).

\(^{16}\) Leslie Sillars. ‘The New Religion of Computer Consciousness.’ Salvo Magazine http://www.salvomag.com/new/articles/archives/science/sillars.php accessed Dec 25, 2016.

\(^{17}\) University of Chicago Medical Center. “Complexity Constrains Evolution Of Human Brain Genes.” ScienceDaily. 29 December 2006. www.sciencedaily.com/releases/2006/12/061226095421.htm accessed Dec 25, 2015.
On the basis of individual neurons of the brain, humans may indeed have a far more active, or even more complex, transcription profile than chimpanzee...we suggest that such abundant and complex transcription may increase gene-gene interactions and constrains coding-sequence evolution.

This means that natural selection is no longer enough to code new advanced genetic sequences. For human populations to improve their “fitness”, intelligent design needs to design new codes. Necessity may indeed be the mother of new inventions.

Let’s examine consciousness for a bit. At a basic level, being conscious means ‘being awake.’ Therefore if your computer cannot wake itself up every morning, it cannot be conscious, right?

Michael Graziano is a professor of neuroscience at Princeton University in New Jersey. His latest book is Consciousness and the Social Brain (Oxford University Press, USA, 2013). In an essay titled, ‘Build-a-Brain’ he describes how human brains perceive objects. For example, if we were to look at a tennis ball bouncing, we would note its color, shape, how high it bounced, the variability of the bounce etc. Our brain constructs something like a dossier, a dataset that is constantly revised as new signals come in. This is what scientists refer to as the “internal model.” However, if we were to ask a robot a few questions regarding the tennis ball, Graziano suggests that the conversation would go something like this18:

We ask: ‘What’s there?’
It says: ‘A ball.’
We ask: ‘What are the properties of the ball?’
It says: ‘It’s green, it’s round, it’s at that location.’ It can answer that because the robot contains that information.
Now we ask: ‘Are you aware of the ball?’
It says: ‘Cannot compute.’

It is this lack of ‘awareness’ that differentiates a computer from a human. It is the inability to understand the abstract or imperfect relationships. However, people developing artificial intelligence view this as a technical or engineering problem rather than an emotional one.

Giulio Tononi at the University of Wisconsin-Madison has been trying to solve this problem of the mathematical theory of consciousness, dubbed the “Integrated Information Theory.” Tononi feels one of the main aspects of human consciousness is the ability to learn from experience; the second is the ability to solve mysteries – everyday relationships are mysteries are they not (Men are from Mars, Women from Venus)? Tononi reckons that unless these problems are solved, a computer cannot be truly conscious and

18 Michael Graziano. Build-a Brain. https://aeon.co/essays/can-we-make-consciousness-into-an-engineering-problem accessed Dec 25, 2015.
Singularity will not be achieved. But what if humans could ‘lend’ a computer some conscious awareness? This has led scientists to develop brain-computer interfaces (BCI). In a first-of-its-kind study, engineers and neuroscientists in India and France recently demonstrated the viability of direct brain-to-brain communication in humans. They successfully transmitted information (words like ‘hola’ and ciao’) via the Internet between intact scalps of two human subjects – located 5,000 miles apart. Explaining their methods in PLOS ONE, they say\textsuperscript{19}:

By using advanced precision neuro-technologies including wireless EEG and robotized TMS (trans-cranial magnetic stimulation), we were able to directly and noninvasively transmit a thought from one person to another, without them having to speak or write.

One of the reasons consciousness has been elusive for otherwise intelligent robots is that consciousness (or to the philosopher, the psyche) is everywhere. Neuroscientist Christof Koch, chief scientific officer at the Allen Institute for Brain Science, talks about the theory of panpsychism – put simply, we are just a mind (or soul) in a world of minds. This was a theory espoused by thinkers like Plato and Spinoza, only to be sidelined by modern society’s quest for empiric science. But a failure to infuse computers with consciousness has reignited this debate. According to Koch, consciousness arises within \textit{any} sufficiently complex, information-processing system and the solution to Singularity may lie in us being connected. In an interview with \textit{Wired} magazine\textsuperscript{20} (rather appropriate, don’t you think), he noted:

The Internet contains about 10 billion computers, with each computer itself having a couple of billion transistors in its CPU. So the Internet has at least $10^{19}$ transistors, compared to the roughly 1000 trillion (or quadrillion) synapses in the human brain. That’s about 10,000 times more transistors than synapses. But is the internet more complex than the human brain? It depends on the degree of integration of the Internet… For instance, our brains are connected all the time. On the Internet, computers are packet-switching. They’re not connected permanently, but rapidly switch from one to another…

Therefore, consciousness = connectivity.

Therein lies the future. Technology now has the capability of making humans communicate via computers without using any of their traditional five senses. Genomes have been mapped. Artificial brains have been created

\textsuperscript{19} Alvaro Pascual-Leone and others. “Conscious Brain-to-Brain Communication in Humans Using Non-Invasive Technologies” PLOS ONE. Published online August 19 2014.

\textsuperscript{20} A Neuroscientist’s Radical Theory of How Networks Become Conscious. WIRED magazine interview with Christof Koch. \url{http://www.wired.com/2013/11/christof-koch-panpsychism-consciousness/} accessed Dec 25, 2015.
for worms and mice that transmit their behaviors to inorganic hosts, even Lego models. We also have the capability to use our thoughts to control robotic bodies. Even if Singularity isn’t here yet, we have reached a new level of human-machine interaction as a halfway measure towards achieving the ultimate goal. For now, this human-computer seems the immediate future and one that will help computers ‘learn’ our way. Will the future be dystopian and Utopian? Time will tell. However, I must say this – when I read Utopia I felt uneasy about the sameness of society portrayed therein. I am not worried about Singularity as long as artificial intelligence can be varied, moody, altruistic and joyful. Isn’t life about celebrating differences?

Over half a century ago, I.J. Good wrote about the dangers of artificial intelligence:

Let an ultra-intelligent machine be defined as a machine that can far surpass all the intellectual activities of any man however clever. Since the design of machines is one of these intellectual activities, an ultra-intelligent machine could design even better machines; there would then unquestionably be an “intelligence explosion,” and the intelligence of man would be left far behind. Thus the first ultra-intelligent machine is the last invention that man need ever make, provided that the machine is docile enough to tell us how to keep it under control.

If you consider evolution by its dictionary meaning – ‘A gradual process in which something changes into a different and usually more complex or better form’ – then the move from natural selection to intelligent design as the architect of biological progress is no different. The problems for human brains will be coping with mathematics and robotics with no specific purpose in mind. In a brave new world of independent thought, some human, some not – there is bound to be a conflict with the most human tendency of all: the need to control other beings. As Vinge noted in his essay right through evolution, the next life form does not pay its dues to previous models:

Any intelligent machine of the sort he (Good) describes would not be human-kind’s “tool” -- any more than humans are the tools of rabbits or robins or chimpanzees.

21 I. J. Good, “Speculations Concerning the First Ultralntelligent Machine”, Advances in Computers, Vol 6, Franz L. Alt and Morris Rubinoff, eds, pages 31-88, 1965, Academic Press.
22 evolution. (n.d.) American Heritage® Dictionary - English Language, Fifth Ed. (2011). http://www.thefreedictionary.com/evolution accessed Dec 25, 2015.
23 Vernon Vinge. “The Coming Technological Singularity: How to Survive in the Post-Human Era.” Proceedings of a symposium cosponsored by the NASA Lewis Research Center and the Ohio Aerospace Institute; held in Westlake, Ohio, March 30-31, 1993.
‘Follow the money’ may be an adage when it comes to solving complicated crimes, but it often gives us an idea where science is leading us. Recently, DARPA, the US Defense Advanced Research Projects Agency announced a $60 million challenge to researchers to create connections between the human brain and computers. Successful teams must create a neural engineering design system – with ‘full-duplex interaction with at least 1,000 neurons – initially in regions of the human auditory, visual, and somatosensory cortex’. The future of the computerized brain is here. One concern is however, security of such a system. Humans can be influenced; computers can be hacked. Therein lies another challenge.

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