Ubiquity Symposium

The Technological Singularity

Human Enhancement—The Way Ahead

by Kevin Warwick

Editor's Introduction

In this paper a look is taken at artificial intelligence and the ways it can be brought about, either by means of a computer or through biological growth. Ways of linking the two methods are also discussed, particularly the possibilities of linking human and artificial brains together. In this regard practical experiments are referred to in which human enhancement can be achieved though linking with artificial intelligence.

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Classical studies in artificial intelligence (AI) have focused on the development of intelligence in machines which is an attempt to copy human intelligence. Indeed the traditional definitions of "weak AI" and "strong AI" [1] both pamper to the belief in some humans—who in many cases turn out to be computer science or philosophy professors—the best that can ever be achieved is a form of AI that merely approaches that of human intelligence and human intelligence is obviously the ultimate.

This approach can perhaps be best seen in Minsky's definition of AI: "Artificial intelligence is the science of making machines do things that would require intelligence if done by men" [2].

Such a narrow vision has been supplemented, as pointed out by Turing [3] in his "Argument from Disability," in that whatever abilities that a machine may have in terms of its thought processes, it will never be able to. Therefore examples given are such as tell a joke or have a sense of humor[4]. For some reason there appear to be people who subsequently wish to conclude that because a machine cannot tell a joke, if indeed that was the case, which it is not [5], then that's all there is to it—the future is safe for humans [6].

One might think when Turing cleared the air with his "disability argument" more than 60 years ago, intelligent humans would heed his important words and not fall into the simple trap. But many years on, it still happens on a regular basis. A wonderful example comes from 1983 when two CMU Professors published a book in which they claimed machines will never be able to dance a ballet, peel a grape, darn a sock, play championship table tennis or deliver a baby [7]. (No, I am not making this up!) Obviously Turing was not on the syllabus at CMU, let's hope things have changed.

But various luminaries have also helped to stoke the problem. Carl Sagan for example, having pointed out intelligence only evolving once—in humans [8, 9]. The resultant conclusion, that there is only one form of intelligence (the human kind), thereby fuels the fire for the classical AI scholars.

However, as Turing himself stated, the machine kind of intelligence is something quite different to human intelligence in the way it functions and (usually) on the platform on which it is built. While it is certainly an interesting question to consider whether artificial intelligence can actually replicate, or even appear to replicate, human intelligence, far more important questions are: Is it likely to get out of control? If so, when could this happen? Is there anything we can or should do about it? Merely putting our head in the sand and hoping everything will go away is not the best remedy.

Already there are many ways in which the standard form of AI surpasses that of human intelligence—mathematical abilities, speed of information processing, memory abilities, the range of sensory input and the ability to think in many dimensions are just some of these. Clearly we are looking at a complex issue such that overall intelligence is a multi-faceted entity. With animals and other creatures it tends to originate in a stand-alone form. An intelligent creature, such as a human, can be individually terminated. However where numbers are great and many are driving collectively in the same direction, as was experienced by the Native Americans when Whites arrived in great numbers during Westward expansion in the 19th century, then the tide can be difficult to stop.

With AI however we are dealing with a networked form of intelligence, something that even Turing did not apparently point to. As a result even now we have machines that we cannot turn off, that we are not completely in control of—the Internet is a good example of this. Yes in theory it might be possible but in practice? One reason for this is humans are directly dependent on the technology being functional and operative on a regular basis. It is designed to protect itself against malevolent signals, it is designed to stay functional even when power is removed, it is designed to prioritize and make decisions for itself. Important aspects of AI are that it can learn, adapt, and achieve goals, often in ways that are difficult and sometimes presently impossible for humans to understand. Particularly if the experience of the AI in question is different to that of humans, which it probably will be due to sensory differences alone.

But of course thinking in terms of AI acting against us and taking over is merely one possibility. The old adage “if you can’t beat it, join it” clearly comes into play at this juncture. In other words, is it possible to upgrade the functioning of a human brain by linking it directly with a computer network and if so, what exactly is on offer—not some time into a science fictional future, but here and now.

Fortunately experiments in just this direction have been going on for some time and hence we can have a look at what has already been achieved and what looks as though it might be possible with a little bit of effort. So, what are the possibilities? Well here are a few examples:

- Enhanced memory
- Enhanced communication
- Enhanced senses
- Multi-dimensional thinking
- Extending the body
- In built machine thinking
- Enhanced maths + speed of thinking + problem solving

Clearly a couple of these are a little speculative and perhaps some way off, a good example of this would be linking a human brain with a computer network in order to think in many more dimensions than 3-D, which humans are limited to at present. Perceiving ones surroundings in 20 or 30 dimensions will allow for a much more complex understanding and thereby could rapidly change abilities to interact and move around in it. But as far as the author is aware, no such experiments have as yet occurred.

However in others the first steps have already been taken with results available. For example in terms of extending the body, we have witnessed how this can be achieved both in monkeys [10] and humans [11]. In the human case, with the subject in New York City (Columbia University to be precise) they were able to control the movements of a robot hand in England (Reading University) by means of their own neural signals fed through an implanted electrode array. Coupled with that, in a series of experiments, they learned to perceive sensory data from the robot hand fingertips in order to apply closed loop control. This means for humans that a person's brain and body do not have to be in the same place.

Directly enhancing human senses has also been witnessed in a number of ways. Indeed it could be considered that with external signal modification, such as in infra-red night sight or even standard X-ray machines, the human brain adapts to understand and takes direct information from such signals [12]. As far as implants are concerned, if we are interested in enhancement rather than mere therapy, even magnet implants could be regarded in this light [13], where ultrasonics and infrared can be converted to an internal touch sense. But it is when external sensory signals are fed to directly stimulate the nervous system by means of implanted

electrodes that the brain adapts quickly to take on board a new or extended sense in its own right [14].

Perhaps the most encouraging of those upgrades already tested would be in the field of communications. At present, in comparison with technology, human communication is extremely poor. Essentially highly complex and poorly understood electrochemical signals in the brain are converted into mechanical movements, which result in changes in serial sound (pressure) waves that are relatively slow, error prone, and disperse over a short distance. On top of that the noises actually produced bear little relationship to the original thoughts. Although technology (the telephone for example) has enabled the distances involved to be increased dramatically, it is still the case that signals such as emotions, feelings, thoughts, images, concepts, and so on cannot be transmitted from brain to brain in anything like their original form. The way ahead has to be direct brain-to-brain communication. Fortunately experiments, involving direct radio telegraphic communication between human nervous systems, have proved to be successful [11], and as a result we can look forward to the first direct brain-to-brain communication before very long due to ongoing research in this direction [15]

Ray Kurzweil may well be right that we need to hook up human brains with technology in order to stay in the driving seat [16]. Otherwise a raft of technologists point to one form or other of the singularity occurring with intelligent machines taking over control [17, 18, 19, 20]—it is merely a case of how and when rather than if.

Enhancement is one answer, but there is another—a whole body transplant or a brain transplant, whichever way you wish to look at it. Indeed such has been suggested by Hans Moravec [21]. But is this mere speculation? Perhaps yes, but not as much as one might think. Already neurons, of the human kind, can be cultured and embodied within a robot platform—not too far from Moravec's original thoughts. At present the reality of culturing [22, 23] involves maybe 100,000 brain cells, thereby not approaching the estimated 100 billion in a human brain. But these can be highly connected human neurons, and with the latest 3-D latticed culturing techniques this takes the number up to 30 million. As is the case with hard line AI, it would appear it is merely a matter of time before technology allows for the full works.

So it is possible that in the future you will have a choice. Maybe you would like to remain a human just as you are, possibly ending up as a pet if you're particularly lucky. Or maybe you would like the option of a simple upgrade by means of a neural implant, why not take it step by step if you can. Alternatively there is the "full monty" option, simply get rid of your worn out human body and have a new shiny one in its place. My own feeling is to remain competitive

you'll need both the new body and the implants, but if you stay as you are….well you might as well enjoy yourself while you still can.

About the Author

Kevin Warwick is Deputy Vice Chancellor (Research) at Coventry University, UK, where he is responsible for the University's research portfolio. His own main research areas are artificial intelligence, biomedical systems, robotics and cyborgs. Due to his research, which involved himself as a self-experimenter, he is frequently referred to as the world's first Cyborg. He was born in Coventry, UK and left school to join British Telecom, at the age of 16. At 22 he took his first degree at Aston University, followed by a Ph.D. and research post at Imperial College, London. He subsequently held positions at Oxford, Newcastle, Warwick and Reading Universities before joining Coventry. Kevin is a chartered engineer who has published well over 600 research papers and his experiments into implant technology led to him being featured as the cover story on the U.S. magazine, *Wired*. He has been awarded higher doctorates (D.Sc.) both by Imperial College and the Czech Academy of Sciences, Prague. Kevin has also been awarded seven honorary doctorates by universities in the UK. He was presented with The Future of Health Technology Award from MIT, received The IEE Senior Achievement Medal, the IET Mountbatten Medal, and in 2011 the Ellison-Cliffe Medal from the Royal Society of Medicine. In 2000 Kevin presented the Royal Institution Christmas Lectures, entitled "The Rise of the Robots."

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References

[1] Searle, J. *The Mystery of Consciousness*. Granta Books, 1997.

[2] Minsky, M. (ed.) *Semantic Information Processing*. MIT Press, Cambridge, 1968.

[3] Turing, A.M. Computing Machinery and Intelligence. *Mind* 59, 236 (1950), 433-460.

[4] Rickman, P. The Philosopher as Joker. *Philosophy Now* 25, Winter 99/00 (1999).

[5] Shah, H., et al. Can a Machine Tell A Joke? In *European Conference on Computing and Philosophy (E-CAP 2008)* (June 16-18, Montpellier, France). 2008.

[6] Rooney, B. Why Robots Will Never Take Over the World. *Wall Street Journal*. March 15, 2012.

[7] Ayres, R, and Miller, S. *Robotics: Applications and social implications*. Ballinger, Cambridge, MA, 1983.

[8] Sagan, C. et al. A Search for Life on Earth from the Galileo Spacecraft. *Nature* 365, *6448* (1993), 715-721.

[9] Sagan, C. The Abundance of Life Bearing Planets. *The Bioastronomy News* 7, 4 (1995).

[10] Nicolelis, M, and Chapin, J. Controlling Robots with the Mind. *Scientific American* 287, 4 (2002), 46-48.

[11] Warwick, K. et al. Thought Communication and Control: A first step using radiotelegraphy. *IEEE Proceedings – Communications* 151, 3, (2004), 185-189.

[12] Clark, A. *Natural Born Cyborgs*. Oxford University Press, Oxford, 2004.

[13] Hameed, J. et al. A Novel Human Machine Interface Using Subdermal Magnetic Implants. In *Proceedings of the Ninth IEEE International Conference on Cybernetic Intelligent Systems*. (Sept. 1-2, Reading, UK). IEEE, 2010, 1-5.

[14] Warwick, K. et al. An Attempt to Extend Human Sensory Capabilities by Means of Implant Technology. In *Proc. IEEE International Conference on Systems, Man and Cybernetics*, *Vol.2* (Oct. 10-12, Hawaii). IEEE, 2005, 1663-1668.

[15] Kurzweil, R. The Coming Merging of Mind and Machine. *Scientific American* (1999).

[16] Vinge, V. The Coming Technological Singularity: How to survive in the post-human era. In *VISlON-21 Symposium* (March 30-31). NASA Lewis Research Center/Ohio Aerospace Institute, 1993.

[17] Warwick, K. *March of the Machines*. Century, London, 1997.

[18] Joy, B. Why The Future Doesn't Need Us. *Wired* 8, 4 (2000).

[19] Brynjolfsson, E, and McAfee, A. *Race Against the Machine*. Digital Frontier Press, 2011.

[20] Moravec, H. *Mind Children*. Harvard University Press, Cambridge, 1988.

[21] DeMarse, D. et al. The Neurally Controlled Animat: Biological brains acting with simulated bodies. *Autonomous Robots* ll,3 (2001), 305-310.

[22] Warwick, K. Implications and Consequences of Robots with Biological Brains. *Ethics and Information Technology* 12, 3 (2010), 223-234.

[23] Warwick, K. *I, Cyborg*. University of Illinois Press, 2004.

