International Journal of Artificial Intelligence and Neural Networks– IJAINN
Volume 5 : Issue 1 [ISSN : 2250-3749]
Publication Date: 30 April, 2015

Artificial Intelligence and Economics: from Homo Sapiens to Robo Sapiens

Ad J.W. van de Gevel and Charles N. Noussair

***Abstract* –The integration of artificial intelligence into daily life and the production of goods and services will have large effects on the economy. In the future the labour market will change, with large differences in impact between sectors.**

***Keywords* – singularity, methuselarity, robotics, whole brain emulation, artificial life, artificial consciousness, artificial happiness**

I. Definition and scope of Artificial Intelligence

The term Artificial Intelligence (AI) was coined in 1956 by John McCarthy, who defined AI as the science and engineering of making intelligent machines, which exhibit reasoning, knowledge, planning, learning, communication, perception and the ability to move and manipulate objects. AI systems encompass much more than the traditional computational possibilities to realize all kinds of objectives such as adequate reasoning, strategic acting, problem solving, taking decisions under uncertainty, directly communicating in foreign languages, possessing self consciousness. It has been argued that intelligence is the greatest power in the universe and that it is only a question of a few centuries before intelligence will satiate all matter and energy.

Human biological intelligence is limited and eventually its capacities will be exceeded by non-biological artificial intelligence. A principal part in this process is accelerating and exponentially developing computer capacity Over time the rate of technological progress will become almost infinite, a ***Singularity***. Kurzweil (2005) considers AI the most relevant mechanism to initiate and to achieve Singularity.

Both authors are affiliated with
Tilburg University, Dept. of Economics,
P.O. Box 90153, 5000LE Tilburg The Netherlands;

AI systems are based on autonomous learning processes of machines (robots) and their adaptive interactions with the environment. A well-known landmark in the development of AI is the Turing Test, which requires that computers be indistinguishable from humans. According to Turing a computer would deserve to be called intelligent if it could deceive a human into believing that it was human.

In early June, 2014, a Russia-based team claimed to be the first to create a program that passed the Turing test with unrestricted conversations. In tests conducted at the Royal Society in London, organized by the University of Reading, the Eugene Goostman computer program which is created by Vladimir Veselov, Sergey Ulasen and Eugene Demchenko managed to persuade 33 percent of people that it was a 13-year-old boy from Odessa, Ukraine. (of course, a 13-year-old would not have to show as much knowledge as an adult)..

However, computers designed to pass the Turing test are not really the cutting edge of technology for AI, but rather a collection of tricks to emulate thinking. . Although AI has yet to prove that artificial thinkers do exist, it has already altered the way in which AI scientists look at the act of thinking. Watson, the IBM computer named after its President, was the Jeopardy game show champion and Deep Blue did defeat chess champion Gary Kasparov.

Nevertheless, we are still far away from a computer being human. To do that the computer would need to look like us as conscious beings, walk and talk and act like us, and successfully mimic our emotional, moral and empathetic responses.

With respect to the question whether a computer may be called intelligent there are two possibilities. On the one hand, there may be some practical limit to the capabilities of computers or that there is some special quality of the biological human mind, which is necessary for thinking, that cannot be duplicated by a machine. On the other hand, if the human nervous system obeys the laws of physics and chemistry, then it might be possible to reproduce the behavior of the nervous system with some physical device. According to Kurzweil this last option is possible by 2029.

However, the crucial question is whether a computer which only reshuffles the binary numbers of zero and unity is capable of creating consciousness. iIt is already possible for robots to express emotions in a limited way. E.g., when left alone, the robot Kismet looks sad, but when it detects a human face it smiles . Kismet does not display the full range of emotional behavior observed in humans. but the capacity for emotion is not all-or nothing. Kismet's limited capacity for emotion is a significant advance over the computers that currently sit on our desks, which by most definitions are devoid of any emotion whatsoever.

Robotics is the study of the design, construction and use of robots. Robots are useful for a number of reasons. Robots do not get bored, sick or tired. Robots can do tasks considered too dangerous or dirty, or indeed impossible, for humans. Robots can operate equipment at much higher precision than humans. Robots may be cheaper in many cases. Robots working together in groups might be able to perform complex tasks with a functionality that exceeds the sum of their parts.

Robots are already used extensively for exploring space, the Antarctic, volcanoes, and underwater. Robots operate as surgical assistants; in factories robots perform assembly activities; robots are used by bomb squads to locate and dispose of bombs (the Mini-Andros). For example, in 1979 a nuclear accident in the USA caused a leak of radioactive material which led to the production of a special robot to handle the leak. Robots are also designed to perform mundane household tasks, such as grass cutting and nursing, and as toys which are programmed to talk, walk and dance. Although most robots in use today are designed for specific tasks, the goal is to make universal robots, which are flexible enough to do almost anything a human can do.

II. Consequences of AI

The accelerating technical progress generated by AI has large implications for mankind and the economy.

1) ***Methuselarity*** is the advent of very long healthy lives with low morbidity. Without age-related illnesses, most deaths will be caused by accidents or catastrophic events, not be preceded by a period of infirmity. Aubrey de Grey (2008) has suggested that aging will be subject to comprehensive postponement by regenerative medicine which partially or completely restores a damaged biological structure to its pre-damaged state. According to de Grey, the transition to Methuselarity will take no longer than a few years to arrive. Modest rates of progress will be sufficient to greatly postpone aging. De Grey predicts that the first thousand-year-old human is probably less than 20 years younger than the first 150-year-old. The first million-year-old and billion-year-old are probably less than a year younger than the first thousand-year-old.

2) ***Whole Brain Emulation (WBE*).** Neuroscientists assume that the functions performed by the mind, such as learning, memory, and consciousness, are due to purely physical and electrochemical processes in the brain. Many neural pathways for specific functions of the brain have been already documented, with the relevant sensory association and motor areas identified. WBE or mind uploading is the transfer of a mind, the mental structure and consciousness of a person, from a biological brain to an external carrier, such as a computer. Substantial mainstream research is being done in the development of faster super computers, virtual reality, brain-computer interfaces, animal brain mapping, and simulation. Super computers are expected to reach sufficient capacity for whole human brain emulation within a few years.

According to Kurzweil, in the 2020s, nanobots will augment our brain with non-biological intelligence, starting with routine functions of sensory processing and memory, moving on to skill formation, pattern recognition, and logical analysis. By the 2030s, the non-biological portion of our intelligence will predominate, because biological intelligence is essentially fixed in its capacity. By the 2040s, the non-biological portion will be billions of times more capable. Gradually we would have effectively uploaded ourselves, never quite noticing the transfer. There would be no “Old Me” and no “New Me”, but just an increasingly capable “Me”. This gradual but inexorable progression to vastly superior non-biological thinking would profoundly transform human civilization.

While in deep sleep, nanomachines would circulate throughout the brain, and replace existing neurons with electronic equivalents. In this case, the person will still be living and interacting with his environment as if nothing has happened and he is clearly alive. Hence, the basic idea is to take a particular brain, scan its structure in detail, and construct a software model of it that is so faithful to the original that, when run on appropriate hardware, it will behave in essentially the same way as the original brain.

An uploaded brain could potentially think much faster than a human. Human neurons exchange electrochemical signals with a maximum speed of about 150 meters per second. Eliezer Yudkowsky of the Singularity Institute for Artificial Intelligence has calculated a theoretical upper bound for the speed of a future artificial neural network. It could, in theory, run about 1 million times faster than a real brain, experiencing about a year of subjective time in only 31seconds of real time.

An important issue is whether an uploaded mind is really the "same" sentience. This is the subject of the Swampman thought experiment[1]. It does appear feasible within the foreseeable future to store the full connectivity of all neurons in the brain within the working memory of a large computing system. According to Nicolas Agar (2011) the probability that it may someday be possible to build a computer that is capable of thought (of strong AI) being true is somewhat less than 1, and he therefore concludes that mind-uploading is prudentially irrational.

3). *Artificial Life*, *ALife*, a phrase coined by Christopher Langton (1995), is an alternative life-form: life made by Man rather than by Nature, using artificial rather than living cells. Alife studies the large domain of biological possible life, that is, life-as-it-could-be, amounting to the practice of "synthetic biology". Because intelligence is a property of living systems, AI might be seen as a subfield of A-Life. In May 2010, Craig Venter and his team of scientists successfully created a synthetic life form for the first time ever using a custom-made string of DNA. Venter and his team used the bioinformatics tool to design the chromosome, synthesized it using the four building blocks of life written into its DNA (the bases Adenine, Guanine, Cytosine and Thymine) and then assembled it in yeast before transplanting it into a recipient bacterial cell. This bacterial cell was then transformed into a new bacterial species. It is the first synthetic cell with a computer as its parent.

For the economy, in general, recent and influential new technologies, such as computer software and nanotechnology, are characterized by a distinctive cost structure. They have very high fixed costs of research and development, and of launching initial production. However, the marginal cost of producing additional units is very low. The production of new AI systems, including autonomous robots, can be expected to generally have this type of cost structure. Initially, for a new class of products, a natural monopoly may briefly exist. Depending on how well a patent regime can be enforced, and experience suggests that this will be very difficult at the global level, new firms will be able to enter after some time. If these firms make products which are close but not perfect substitutes, a situation of monopolistic competition would prevail. Because of the cost structure, two firms making an identical product would not be able to co-exist, so an entrant with a cheaper or better version of the same product can rapidly completely wipe out an incumbent.

The arrival of AI will greatly influence the labor market. Augmentations of humans that increase their productivity will also increase their wages. Inequality between those humans who are augmented and those who are not can be expected to increase.

This should not make human workers as a whole worse off, though workers in some occupations will suffer. First of all, all humans can be expected to benefit enormously from the lower prices that the expected gains in efficiency will create. Economic theory predicts that the mix of human and machine in different industries would follow the Law of Comparative Advantage. This is a principle, usually applied at the level of countries engaged in international trade. Countries export, and may under some conditions fully specialize, in those products which they produce relatively efficiently compared to other products. This has the implication that every country exports some products. This is true even for those countries that are less efficient producing every product than another country.

The same would apply to the labor of man and machines. Even if machines eventually become more efficient at every economically valuable task than humans, humans would still be employed in those sectors, in which their disadvantage in smallest. The resource that is human labor would not go non-

[1] *Donald Davidson (1987)propses the following thought experiment: Suppose Davidson goes hiking in the swamp and is struck and killed during a storm by a lightning bolt. At the same time, nearby in the swamp another lightning bolt spontaneously rearranges a bunch of molecules such that, entirely by coincidence, they take on exactly the same form that Davidson's body had at the moment of his untimely death. This copy, whom Davidson terms 'Swampman', is identical to Davidson.. However, though Swampman will appear to recognize Davidson's friends, he actually will not recognize them, as he has never seen them before.*

demanded. For example, suppose that machines are 50 times more efficient than humans at preparing food but only 5 times as efficient at dentistry; then humans willing to work will continue to find employment as dentists.

Human wages will depend on the particular sector and tasks they perform. When humans and machines are substitutes and machines can be produced at very low cost, human wages in that sector can be expected to fall as demand for them decreases. On the other hand, for tasks where humans and machines are complements, demand for human labor would rise, which would tend to increase wages.

However, the wage changes would be mitigated by workers moving away from sectors in which humans and machines are substitutes into sectors in which they are complements. Furthermore, there might still be some human tasks left where machines are not demanded despite their efficiency. For example, some rich people, for reasons of taste or status, might still want to be served and entertained by real human beings and for such jobs, human wages could rise.

Moravec's paradox refers to the striking fact that high-level reasoning requires very little computation, while low-level sensorimotor skills require enormous computational resources. Moravec (1988) observed that "it is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers or chess, and it is difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility." The mental abilities of a four-year-old – recognizing a face, lifting a pencil, walking across a room, answering a question – are some of the hardest engineering problems to be solved.

In this respect, linguist Steven Pinker (2007) writes "As the next generations of intelligent devices appear, it will be the stock market analysts and petrochemical engineers who are in danger of being replaced by machines. The gardeners, receptionists, and cooks are secure in their jobs for decades to come." Skills that appear effortless may be difficult to reverse-engineer, but skills that require much effort and study may not necessarily be difficult to engineer at all (Marvin Minsky, 1988). Indeed, perhaps the most difficult human skills to reverse engineer are those that are unconscious.

III. Humans vs. Machines?

Over time, technological progress creates opportunities in which people compete using machines, and humans and machines collaborate in order to produce more, to capture markets and to compete with other teams of humans and machines. As Gary Kasparov noted, chess teams consisting of humans plus machines dominate the strongest computers. This pattern applies throughout the economy. The key to winning the competition is not to race against machines, but to win by using machines. Although computers win at routine processing, repetitive arithmetic and error-free consistency, are becoming better at complex communication and pattern matching, computers have three failings. Computers lack intuition and creativity, they may be fragile in uncertain or unpredictable environments, and they are lost when working outside a predefined domain.

The solution for the implementation of the winning human + machine strategy is organizational innovation that leverages both ever-advancing technology and human skills. Simply substituting machines for human labor rarely adds much value or high returns. It only results in small productivity improvements. In order to create value, what is required is to combine workers with digital technology.

Several especially promising ways of mixing human and machine capabilities are listed by Brynjolfsson and McAfee (2011). They include
1) Combining the speed of technology with human insight;
2) Using technology to test creative human ideas;
3) Leveraging IT to enable new forms of human collaboration and commerce;
4) Using human insight to apply IT and their data to create more effective processes;
5)Using IT to propagate newly developed and improved business processes.

It seems unlikely that artificial intelligence could provide a means to increase natural happiness. Artificial intelligence promises to raise material living standards. However, the evidence from the past several decades shows that the huge increase in wealth and consumption that has occurred over that period has not increased happiness. There is no reason to suppose that future innovations would be any different. Furthermore, an increase in average wealth may even decrease average happiness if it is accompanied by an increase in income inequality, which would occur if some individuals can profit from it more than others.

IV. Artificial Consciousness

Consciousness is a term that refers to the relationship between the mind and the world with which it interacts. It has been defined as: subjectivity, awareness, the ability to experience or to feel, wakefulness, having a sense of selfhood, and the executive control system of the mind. Since the appearance of computer technology, computer scientists have dreamed about building a conscious robot. The big issue is whether this is feasible even in principle. Is consciousness a prerogative of human beings, which depends on the material the brain is made of or can be replicated using different hardware? Given the results of artificial intelligence and neural computing, in the near future machines may exceed human intelligence. If human consciousness is attributable to complex neural electro-chemical interactions in the brain, it could become just a matter of time until a machine can achieve self-awareness.

Humans are both conscious and intelligent. However, it is possible to imagine one attribute without the other. An intelligent but unconscious being is known as a "zombie" in both science fiction and philosophy. It is also possible to imagine a conscious non-intelligent being. It would experience its environment as a flow of unidentified, meaningless sensations engendering no mental activity beyond mere passive awareness. Digital computers will almost certainly be intelligent at some time in the future. We may then live in a world full of zombies, with all of the resulting moral and philosophical issues.

The majority opinion in biology and neuroscience is that consciousness results from the chemical and physical structure of humans, just as photosynthesis results from the chemistry of plants. A computer is made of the wrong material for consciousness to arise. In this view, digital computers will never be conscious, even if they are intelligent. Given the current pace of computer evolution and the progress in artificial neural networks, scientists predict that computing systems will reach the complexity of the human brain around 2029. On the one hand, it is still unclear whether there is any true possibility of reproducing consciousness in a machine. On the other hand there is no known law of nature that forbids the existence of subjective feelings in artefacts designed by humans.

V. Conclusions and Possible Futures

When computer scientists succeed in developing intelligent machines that can do everything better than humans can, then either of two possibilities might occur.

First, the machines might be permitted to make their own decisions without human oversight. The human race might easily permit itself to become dependent on the machines. As society and the problems that face it become more and more complex and machines become more and more intelligent, people will let machines make more of their decisions for them, because machine-made decisions will bring better results than man-made ones. Then the machines will be in effective control.

Second, human control over the machines might be retained. Then the average man may have control over certain private machines of his own, but control over large systems of machines will likely be in the hands of an elite which will have greater control over the masses. Since human work may no longer be necessary, the human masses may become superfluous and exterminated if the elite is ruthless. If the elite consist of more compassionate individuals, they may be good shepherds to the rest of the human race. They will check that everyone's physical needs are satisfied, that all children are raised under hygienic conditions, that everyone has a wholesome hobby to keep him busy, and that anyone who is dissatisfied undergoes treatment to cure his "problem." In such a society, engineered humans may be physically healthy, even happy, but they will certainly not be free. Governments may intervene by passing laws protecting human rights from robots and requiring robots to be benevolent.

Genetics, nanotechnology, and robotics will become so powerful that they may spawn whole new classes of catastrophes and abuses, some of which would be feasible for individuals or small groups of troublemakers to initiate. They would not require large facilities or rare raw materials as was the case with nuclear weapons. Knowledge alone will enable the use of them. Hence, there is the danger of Knowledge-enabled Mass Destruction (KMD), amplified by the power of self-replication. There is a risk of an arms race developing over GNR technologies, as it did with the Nuclear, Biological and Chemical (NBC) technologies in the 20th century.

However, each of these technologies offers untold promise too. The vision of near immortality drives us forward. Genetic engineering may soon provide treatments, if not outright cures, for most diseases. Nanotechnology and nanomedicine can address yet more ills. Together they could significantly extend our average life span and improve the quality of our lives.

References

Agar, Nicholas. 2012. On the irrationality of mind-uploading: a reply to Neil Levy; *AI and Society*, 27(4)

Brynjolfsson, Erik, and Andrew McAfee. 2011.Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy, Digital Frontier Press.

Audrey de Grey , 2008, *Ending Aging: The Rejuvenation Breakthrough That Could Reverse Human Aging in Our Lifetime*, (with Michael Rae), New York, Saint Martin's Press.

Kurzweil Ray. 2005. *The Singularity Is Near, When Humans Transcend Biology*; Viking Press, New York, NY, USA.

Langton C. 1995. ed., *Artificial Life: an Overview*, MIT Press, Boston, MA, USA.

Minsky, Marvin. 1988. The Society of Mind, Simon and Schuster, New York, NY, USA.

Moravec, Hans. 1988. *Mind Children*, Harvard University Press, Boston, MA, USA

Myers, David. 2007. Psychology of Happiness, *Scholarpedia*.

Pinker, Steven. 2007. The Language Instinct, Harper Perennial Modern Classics, New York, NY, USA.