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The Singularity Scenario

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Authors: René Mittringer rene.mittringer@arcs.ac.at
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Purpose

Although the term 'Singularity' or 'Technological singularity' has already infatuated both the scientific and the science fiction community alike throughout the 20th century, there is reason enough to report about the ongoing activities in this area. So far it is possible to distinguish between Artificial Intelligence (AI) and related issues and the prospective fusion of emerging technologies such as nano-, bio-, information and cognitive technologies (NBIC) – also referred to as converging technologies. It is assumed that there will be an immense technological and consequently economic shift once those technologies surpass the boundaries of human intelligence in the 21st century.

The Future Will be Different

In 1958, Stanilslaw Ulam, referring to a meeting with John von Neumann, wrote:

> "*One conversation centered on the ever accelerating process of technology and changes in the mode of human life, which gives the appearance of approaching some essential singularity in the history of the race beyond which human affairs, as we know, could not continue.*"

The rapidity of technological change (see Moore 1965; Kurweil 1999) in recent times fuels the expectation that continued technological innovation will have a large impact on humanity in the decades ahead. No matter whether it will be the creation of self-improving artificial intelligence, as first stated in 1965 by I.J. Good, some "superhuman intelligence" (Vinge 1993), or the transfer of the human mind into a computer with the help of emerging technologies, these prospects will merit serious attention:

> *"(…)Virtual reality; preimplantion genetic diagnosis; genetic engineering; pharmaceuticals that improve memory, concentration, wakefulness, and mood; performance enhancing-drugs; cosmetic surgery; sex change operations; prosthetics; anti-aging medicine; closer human-computer-interfaces: these technologies are already available or can be expected within the next few decades. The combination of these technological capabilities, as they mature, could profoundly transform the human condition."* (Bostrom 2005)

As a matter of fact, predicting that a single event will lead to change turning humanity upside down may seem far-fetched. Notwithstanding, we must concede that we are evidencing developments indicating transformative change. Whether this will indeed lead to 'singularity' as a period of growth, to crossing the borderline to 'transhumanism', or to the start of a new epoch is a question not to be answered here.

The following three core topics – according to Kurzweil's book 'The singularity is near' (2005) – were chosen in order to support a feasible 'Singularity Scenario', representing the pro-

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gress of science and technology to be expected within the coming decades:

- genetics,
- nanotechnology,
- robotics.

Genetics - Intersection of Information and Biology

Will we control aging and personal health with the help of genetics? Here are some promising innovations and developments in this field:

- **RNAi (RNA Inferference)**
  Means being capable of turning off specific genes by blocking their mRNA and preventing them from further producing proteins (important for the life cycle of viral diseases, cancer and many other diseases).
- **Cell therapies**
  Regrowing our own cells and introducing them into our body without surgery; "therapeutic cloning".
- **Gene chips**
  Genetic profiling relevant to drug screening and identification, improving cancer classifications, identifying undesired pathways, genes and cells, and determining the effectiveness of an innovative therapy.
- **Somatic gene therapy**
  Gene therapy for nonreproductive cells by effectively changing genes within the nucleus; creating 'new genes'.

Reversing Degenerative Disease

Degenerative (progressive) diseases – heart disease, stroke, cancer, type 2 diabetes, liver disease and kidney disease – account for about 90 percent of deaths in our society. Strategies have been identified to halt or even reverse the underlying processes in each case:

- **Combating heart disease**
  Regrowing our own cells or even organs and introduce them into our body without surgery; "therapeutic cloning".
- **Overcoming cancer**
  The design of cancer vaccines to stimulate the immune system to attack cancer cells seems promising.

Reversing Aging

Key factors of the aging process and reversing strategies:

- **DNA mutations**
  Using gene therapy in order to remove those genes from our cells that cancers rely on to maintain their telomeres in dividing.
- **Toxic cells**
  Methods are being developed to programme "suicide genes" to attack fat cells or "old" cells enabling the immune system to destroy them.
- **Mitochondrial mutations**
  Transferring mitochondrial genes into the nucleus of cell structures to provide a backup for efficient functioning.
- **Intracellular aggregates**
  Strategies using gene therapy to introduce new genes to break down so called 'intracellular aggregates' – toxins within cells.
- **Extracellular aggregates**
  AGEs (advanced glycation end-products) result from undesireable cross-linking of useful molecules as a side effect of excess sugar. These cross-links interfere with the normal functioning of proteins and are *key contributors to the aging process*. Experimental drugs like ALT-711 (phenacyldimenthylthiazolium chloride) can dissolve these cross-links without damaging the original tissue (S.Vasan, P.Foiles, H.Founds 2003; D.A. Kass 2003). Other molecules with this capability have also been identified.
- **Cell loss and atrophy**
  A hybrid scenario involving both bio- and nanotechnology contemplates turning biological cells into computers. These "enhanced intelligence" cells can detect and destroy cancer cells and pathogens or even regrow body parts. Scientists at the MIT Media Lab for instance have developed ways of using wireless communication to send messages, including intricate sequences of instructions, to the computers inside modified cells.

(Human) Cloning

Cloning will be a key technology – not for cloning actual humans (which will probably not be avoidable sometime in the future irrespective of reasonable ethic reservations), but for life extension purposes, in form of 'therapeutic cloning' as mentioned above. Furthermore, cloning will be important for preserving endangered species and restoring extinct ones, for pharmaceutical production (milk of transgenic goats) and human somatic-cell engineering. The latter allows to bypass the controversy of using fetal stem cells by transdifferentiation: by manipulating proteins or rather understanding their RNA fragments and peptides, gene expression can be controlled. Perfecting this technology will also defuse the ethical and political explosiveness of this issue.

Nanotechnology - Intersection of Information and the Physical World

"The principles of physics, as far I can see, do not speak against the possibility of maneuvering things atom by atom." (Feynman 1959)

Along with the progress of full-scale nanotechnology, there will be potential to replace biology's genetic-information repository in the cell nucleus. A nanoengineered system would maintain the genetic code and simulate the actions of RNA, the ribosome, and other elements of the computer in biology's assembler. A nanocomputer would maintain the genetic code and implement the gene-expression algorithms. A nanobot (a small robot) would then construct the amino-acid sequences for the expressed genes. Such a nanoengineered system would allow turning off unwanted replication and thereby defeating cancer, autoimmune reactions and other disease processes. Nanobots in the bloodstream are another example. Seemingly futuristic, many such micro-scale devices are already functional in animals.

Apart from replicating biological molecular-assembly capabilities, molecular manufacturing pursues another goal: to improve computation. The switching speed of nanotube-based computation would greatly exceed the speed of electromechanical switching. Furthermore, there is tangible progress in the actual construction of molecular machines.

Another focus will be on the development of clean, renewable, decentralised and safe energy technologies made possible by nanotechnology and, on the other hand, to use nanotechnology to increase energy efficiency, e.g., basic energy transmission, wireless transmission of energy by microwaves, for hydrogen fuel-cell powered cars or solar power (see also: The Millennium Project of the American Council for the United Nations University, 2004 report of the U.S. Department of Energy).

Promising as well is the creation of new manufacturing and processing technologies that will dramatically reduce undesirable emissions.

Robotics: Strong AI

The third topic, or rather revolution, in the GNR bundle is Robotics or strong artificial intelligence (strong AI). It shows parallels to the human duality of body and mind. However, the core aim is to create artificial intelligence exceeding human intelligence and robotics would be its embodiment.

Another key question is whether strong AI will lead to full nanotechnology (molecular-manufacturing assemblers that can turn information into physical products), or will full nanotechnology lead to strong AI; whereas the first scenario could help solve remaining design problems of enhanced nanotechnology, the latter indicates the so far insufficient hardware applications for strong AI.

There are already several simple forms of AI techniques available such as character recognition, speech recognition, machine vision, robotics, data mining, medical informatics and automated investing, but the essential barrier to strong AI is developing sufficiently detailed models of how human brain regions work in order to design AI properly (reverse engineering of the human brain or natural intelligence). Machine intelligence might be good in consistently performing peak levels and skills or in pooling resources, but it is still pretty weak on parallel pattern recognition. Without any doubt, a task humans are still far better capable of performing.

Approaches or tools usually considered to overcome this shortcoming are:

- expert systems,
- Bayesian nets,
- Markov models,
- neural nets,
- genetic algorithms (GA),
- recursive search and
- combining methods.

Fields where "narrow forms" of AI are already showing considerable progress are:

- **Military intelligence**
  U.S. military intelligence uses pattern-recognition software systems to guide autonomous weapons, and unmanned robotic flying fighters were used in the 2003 Iraq war.

- **Space exploration**
  The *Deep Space One Mission* in 1999 used AI-based systems capable of reasoning through new situations rather than just following pre-programmed rules. Another NASA AI system called Moving Object and Transient Event Search System (MOTESS) learned on its own to distinguish stars from galaxies with an accuracy surpassing that of human astronomers. Similar systems are obviously found again in military applications for detecting spy satellites or the like.

- **Medicine**
  Applications in medicine are in automated ECG analysis tools, intelligent data mining and pattern recognition for the development of new drug therapies, detection of diseases and development of therapies, or complex expert systems for differential diagnosis; e.g., evaluating possible allergies caused by drug interactions.

- **Science and math**
  Applications in this area are AI based systems capable of formulating theories, robotic systems that can automatically carry out experiments and finally a reasoning engine that evaluates results.

- **Business, finance and manufacturing**
  AI systems are used to control and optimise logistics (e.g., Wal-Mart, Ascent Technology's SAOC system), detect fraud and money laundering (NASDAQ's SONAR system), and perform intelligent data mining.

- **Manufacturing and robotics**
  Computer-integrated manufacturing (CIM) uses AI techniques to optimise the use of resources, streamline logistics and reduce inventories by just-in-time purchasing of parts and supplies. The newest trend here is to use "case-based reasoning" rather than hard-coded, rule based expert systems.

  Robots are extensively used in manufacturing and they in the meantime use AI-based machine-vision systems enabling autonomous interaction and navigation. Consequently, military use is also in the line of this development.

- **Speech and language**
  Probably one of the biggest challenges to AI is to cope with natural language. Google and other search engines use AI-based statistical learning methods and logical inference to determine the ranking of links. The real barrier for such search engines is inability to understand the context of words. Microsoft has developed a natural-language search engine called Ask MSR (Microsoft Research) to answer natural-language questions. And at least 75 percent of the time the correct answer is among the top three ranked positions.

  Computer language translation, for instance, also continues to improve gradually, but it will be one of the last application areas to fully compete with human capacities.

Already more advanced are so-called virtual agents capable of appropriately responding (usually via phone or equivalent services) to an asking counterpart. Companies such as British Airways and Verizon use these systems for customer services while Charles Schwab and Merrill Lynch use them to conduct financial transactions.

The various examples in the section above show that the performance of AI is continually progressing and expanding, while the range of tasks in which machines compete with human intelligence is growing larger and larger.

Conclusio without Ultima Ratio

Considering policy issues, the task is to develop appropriate measures such as **legal and ethical standards**. Certainly, it will be a trade off between technological progress and balancing the risks for human society that policy makers have to keep in mind. However, regardless of the measures taken, regulation, as a matter of fact, will be busy just trying to keep pace with fast-moving technological progress. Far from being able to control this development, government has to prepare at least a 'best response' to speak in terms of game theory. In light of these challenges to traditional conceptions of self-regulatory evolution of human kind, the singularity assumptions proposed in this brief will require rigorous measures and defensive steps to avoid undesirable and even sometimes inevitable risks of progress.

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