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The Singularity Challenge
- When will Interpenetration of Internet, Artificial Intelligence, Computer Farms, Data Centers, Devices/Things, etc. take over Innovation?

Prof. Dr. Ludwig Nastansky
University of Paderborn / CDHK Tongji University, Shanghai
ln@gcc.upb.de

Key points

- The Technological Singularity - and why to deal with it in business
- What are and who is doing "innovations" in business
- Disruptions and inflection points caused by technological innovations
- Exponential progress of computing based technologies
- Human perception failures about accelerating growth phenomena
- Law of accelerating returns
- Human vs. artificial intelligence
- Deep Learning

"Computing speed doubles every two subjective years of work. *Two years after Artificial Intelligences reach human equivalence, their speed doubles.* *One year later, their speed doubles again.* *Six months - three months - 1.5 months* *... Singularity."*		
Eliezer Yudkowsky, Staring at the Singularity, 1996	Computer Farms / Data Centers: Not that easy to get around, at least physically.	Kai Yu, at Baidu's Research Center in Silicon Valley: Making a point on Deep Learning.

Abstract

The world experiences an ongoing interpenetration of

- internet, machine intelligence, software and app layers,
- computing concentrated in huge computer farms as well as distributed over an increasing number of decentralized and connected devices/things with ever growing performance at all ends,
- big data, things, etc.

This intermeshing progress in information technology (IT) poses many challenges. It continues to disrupt existing businesses, whole industry sectors, or business models whose rules were taken for granted according to existing business wisdom for a long time. In addition, again against business and economic research tradition, speed and intensity of the underlying processes apparently follow a "Law of Accelerating Returns". All this has enormous impacts on our socio-economic environment - and humankind. Given all the zillions of details of the versatile processes concurrently driving current IT-progress, the question of a comprehensive understanding about now and the future arises.

A growing group of futurists, scholars, experts, or business people in different areas ranging from IT, industry, business, or economics over to sociology, history, or philosophy for some time has an answer to the question

"Where will all this IT-progress lead to?": Mankind is reaching another inflection point, this time a "Technological Singularity". The singularity implies that the combined "intelligence" and "thinking performance" of computing systems in the world will have surpassed the corresponding mental equivalent of mankind. After the singularity has happened (2045 ?), everything will be different. In the presentation important forces driving this development will be pointed at. This includes: current hype areas in industry (like "Industry 4.0" or Nanotechnology), explosion of data centers, challenges to really understand phenomena like accelerating acceleration, "Deep Learning", facets of the "Technological Singularity" - and some aspects around what can be learnt from this for current operational and strategic planning in business.

The presentation in a top-down manner is intended to convey anti-intuitive impressions, give hints of how to bring things together, and offer material for further brainstorming in the participants' respective areas of expertise. The overall view of the presenter about approaching the Technological Singularity is positive, putting the tremendous opportunities in the foreground IT-progress offers. Thus, to deal with the unquestionable enormous challenges of this development is left for another place. As to the research approach to the outlined topics: the presentation is more on the "relevance" side than rigorous.

Short Paper

Understanding the power of accelerating trends in technology

Current innovation in products and services is driven to a far extent by people and organizations actively exploiting technological developments, progress in Business Management or Economics theories only playing a secondary role. We experience, on the one hand, developments in the physical world with advances in areas like manufacturing, supply chain configuration, product design, chemical processing, bio-engineering, or prospects of completely new materials. "Industry 4.0" or "Nano Technology" are just some of the ample examples which epitomize these developments. On the other hand, in the virtual world, we are active and passive agents of apparently never ending and accelerating cycles of progress in computing technology, hardware, software, new devices, automation, or dissemination of internet based services. Together these enable, enact, or support most of the industrial advances of the physical world in the meantime. This trend is epitomized by "Moore's Law", which states in its more generalized interpretation that every two years, or so, computing performance doubles - taking together miniaturization, speed, memory capacity, upscaling in computer farms and data centers, software advances, machine intelligence, etc.. As is commonly known, there is no scientifically proven thesis behind "Moore's Law", originally stated for density acceleration in integrated circuit technology by Intel Corp.'s co-founder Gordon E. Moore in a paper in 1965. But, curiously enough, the implied proposition of a cyclical doubling growth rate with a period of roughly two years holds since that time.

The human mind is not well prepared, if able at all, to intuitively perceive or naturally judge on the phenomenon of accelerating speed of everyday things caused by exponential growth, hyperbolical developments, or exploding network intermeshing. Doubling cycles of biannual performance increases in computing systems according to "Moore's Law" have already happened for 50 years. This implies, to point out just one arbitrary example of the implied growth amplification, that in 2015 we can wear a 1985 super-computer (Cray-2) on our wrist (Apple Watch) - a trillion-fold rise in performance evoked over a time span of 30 years by the principals underlying a biannual doubling cycle (#1).

In this presentation, some challenging aspects of this growth acceleration will be broken down to main themes discussed at the "German-Sino Management Innovation Conference", such as innovation, technological development, or general management. For all these typical and accustomed traditional business areas a man-machine cooperative pattern prevails, at least so far. Management staff and employees on all levels depend on using computing systems to fulfill their daily tasks. Thereby, the computing environment extends in complexity from operational tools at workplaces in offices or engineering departments, over semi or fully automated processes in all business areas, to strategic endeavors enabled by big-data thrown at data-mining systems. The latter making more and more use of machine intelligence mechanisms. As more complex the computing systems in-house or facilities outside the company ("in the cloud") turn out, as more distant and alienated the company's stakeholders appear in understanding all details and functional options of the systems they use and depend on. Especially, even experts tend to not completely, if at all, see through how overall condensed and aggregated results, brought back as action plans to decision makers and clerical staff alike, are algorithmically produced from which data. Hence, it is not all too speculative to judge that in the history of man-machine interaction with business computing systems we currently experience that

more and more is done on the side of the computing systems. It is accomplished automatically, not directly controlled by people, in rather "intelligent" ways, without human interaction. In particular, this trend of growing computer dominance and independence will continue.

A challenging issue, not only for strategy thinkers in a company, is how this trend that intermeshed computing systems continue to automatically unfold their intelligent power with accelerating speed can be understood, characterized, modeled, and possibly exploited in the portfolio of corporate strategies and decision making. Already now, for the majority of users, computing systems take the role of "gray box" or even "black box" entities: Do employees using all abundant "Google search" really understand how the list of findings is produced or ranked, which data are underlying, which algorithms are used, or even which moral/ethical judgements are employed during the search and result rendering processes? But, for an ever growing community of researchers, engaged individuals, and dedicated organizations, the underlying general question in which direction the accelerating performance growth of computing systems will evolve and can be understood best has had a tantalizing answer already for some time: We will enter a "Technological Singularity". Theorists and advocates thinking in terms of this computing centered singularity occurrence have been around for some decades. So far, they mostly saw themselves positioned on the more speculative side of forecasting upcoming future developments. But, currently, it seems they are about to approach mainstream.

The Technological Singularity

The Technological Singularity, in its pure interpretation, states that we will enter a disruptive crossing point when the world's computing systems altogether will have surpassed the "thinking" power of the human race and have become as "intelligent" as all humans together. "Moore's Law" implies that after this inflection point computing performance will double in its usual way during the next development cycle of two years or so - computing systems are still "thinking" in the performance scale of humans. But, the following cycle of doubling computing performance lasts only one year because of the doubling in computing performance in the preceding cycle. In this second cycle, computers do the "thinking" already with double speed compared to human time measures. The subsequent cycles consequently follow a (hyperbolic) sequence of half a year, a quarter of a year, etc.. This event chain is leading to a typical instability transition which has been known in mathematics and physics as "Singularity". Mankind has experienced accelerating changes and singularity inflection points in the past: From the Middle Ages to the Age of Enlightenment, or from handwork to the Industrial Revolution, to name just two. So, the Technological Singularity, first pointed at by Vernor Vinge in 1993, is by its essence not as far-fetched as it looks at the first glance.

In a more moderate interpretation, the ever accelerating performance and capability spectrum of computing systems will lead to man-machine systems in organizations where employees seamlessly augment and amplify their intelligence and, not the least, innovative power at the workplace. More precisely, the assimilation of business tasks in corporate computing systems and work force will make it indistinguishable who is "leading" in operative, tactical, or strategic processing. The question which side is "really" doing decisions, or innovation moves for example, is blurred and meaningless. The complex meanings of "intelligence" and "innovation" in this context need to be and will be exploited more closely in the presentation.

One justification for this presentation is that most, if not all, of the current developments around computing systems and internet tellingly support the singularity proposition. We have already entered a phase where the interpenetration of internet, hardware and software systems, machine intelligence, computer farms, big data, data centers, devices/things, etc. has taken over many endeavors so far reserved only to humans. Just think of the technological side in complex industrial innovations, which currently with "Industry 4.0" have entered the "Hype Phase", according to Gartner Inc.'s hype cycle research curve. The underlying development forces are accelerating in speed. Mechanisms following a "Law of Accelerating Returns" (Raymond Kurzweil) are feeding the progress, as opposed to the "diminishing returns" following classical business and economics wisdom.

Example: Current breakthrough growth with "Deep Learning"

A benchmark arena for these developments and the approach of the Technological Singularity is "Deep Learning". After decade long cycles of hype and more or less complete disappearance of using neural networks in artificial intelligence, all in a sudden a complete change has happened. Since some five years, in many computer labs, research institutions, or startup businesses around the world the underlying core concepts of neural networks have not only proven to be spectacular successful for

real life applications, but furthermore look extensively promising for upcoming developments. This dramatic change has been enabled by bringing together advances and trends in disparate areas, as for example research, computing, or big data. Research advances and algorithmic (re-) design have lead to the current breed of neural algorithms, with capabilities like unsupervised or semi-supervised feature learning and feature extraction using a sequence of hierarchical filter layers. In computing the use of GPUs (graphical processing units) instead of "classical" CPUs (central processing unit) for the core computational tasks in these algorithms has sped up computational efficiency by a factor of 30-50. So, as an irony, for some five years it is not anymore Intel Inc., Gordon Moore's home company, helping to sustain the empirical proof of Moore's law, but rather NVDIA Inc., meanwhile worldwide leading in GPU design and production. And, not at last, "big data", man made or out of the physical world, are now easily available via internet to sufficiently feed the neural nets for their learning phases and thus training them for future pattern recognition tasks.

Global players in teaching, research, and business are feeding this accelerating deep learning revolution. As it looks, they do not act contained in the trenches of their own institutions. Rather they express themselves in a cooperative, open, and global manner. Currently, at Stanford University, the "CS 229 Machine Learning" course in the NVIDIA(!) - Auditorium with some 750 students is the most attractive one. Leading pioneers in deep learning research have joined global internet companies: Geoffrey Hinton (University of Toronto) has joined Google, Yann LeCun (New York University) has become head of AI research at Facebook in 2013. The Chinese search giant "Baidu" tackles deep learning in their recently founded Silicon Valley research lab. Steve Jurvetson, according to Forbes magazine and Deloitte Consulting one of the leading Venture Capitalists (Baidu, Skype, SolarCity, Tesla Motors, Tumblr, Twitter and Yammer), is heavily investing in deep learning startups. Application areas include, amongst many others, image processing, speech processing including real-time translation, analysis of medical data with related diagnosis and therapy processes, law, robotic control, data mining, autonomous navigation, or bioinformatics. The outcome of these endeavors is regularly eye catching, quite often spectacular: In the "cat" project with the "Google Brain" computing system (16'000 GPUs) some 10 million videos on YouTube were used over three days to train their deep learning neural net. In this unlabeled search approach the visual features of "catness" were the result. Current state of the art is, that unsupervised deep learning computing can train features for some 10'000 categories. There is no question that the results of all these efforts will lead to just another phase of disrupting industries. The several approaches for data mining, which have been used for some time in business, will experience a development leap by their extension to unstructured data, most of them provided as an ever growing stream of "data nuggets" out of social networks.

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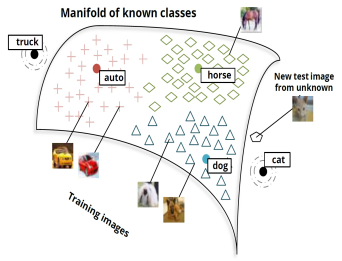
<td> 
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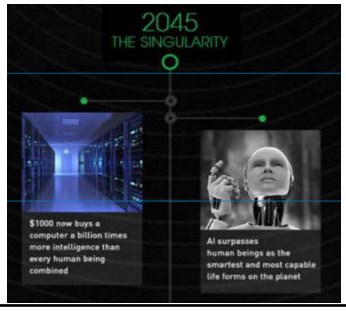
<td> 
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<td>What Yudkowsky means with
Real Big Numbers:

Not tiny ones, like ...

the number of atoms in the universe,
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Why look at events currently happening around the Technological Singularity ?

So it is time to look more in detail what the singularity proposition is all about and what can be, perhaps, practically exploited out of the many underlying key aspects for business right now. For sure it will allow us to escape the locked-in thinking in typical bottom-up incremental evolutionary paths we are used to, and forced to, in our daily business groundwork. Looking at the Technological Singularity offers a unique top-down perspective on the ever accelerating and disturbing bits of computing and internet developments. A singularity, by its essence, does not imply evolutionary development but complete disruption.

Another justification for a singularity discussion in the context of innovation management in this conference is that so far the singularity topic is tainted with a prejudice pattern of being plainly futurist,

esoteric, unscientific, or not-out-of-the-real-world. Protagonists like Raymond Kurzweil or Jürgen Schmidhuber, AI Lab. at ITSIA, Lugano/Switzerland, not refraining from showmanship, have helped to nurture this impression. So, in the current arena of prevailing research publications in business we rarely find papers, if any, dealing with the singularity topic. This is in contrast to growing business adaption in innovative high-tech environments, such as in the computer industry, nanotechnology, or disruption-aware management circles - as hinted at with the "Deep Learning" example. Kurzweil has been one of the leading figures in the singularity arena for over a decade; he is currently technical director at Google. The "Singularity University", located at a NASA research park, is actively organizing global "Singularity Summits" on innovation, bringing together entrepreneurs and innovators. Their he next summit will take place in Amsterdam in Nov. 2015 (#2).

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