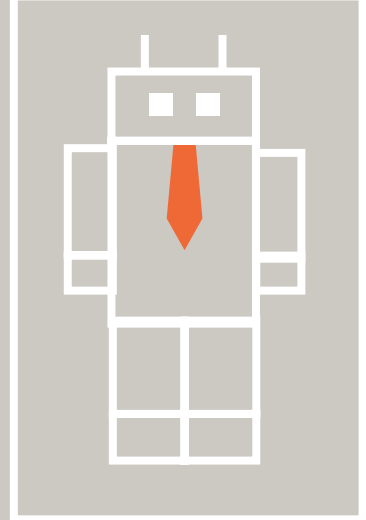




Executive Introduction

Menno van Doorn, Jaap Bloem, Sander Duivestein, Erik van Ommeren

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We thank the Oxford Internet Institute (OII), for insights and ideas that came out of our collaborative Machine Intelligence workshop, specifically: Luciano Floridi (Director of Research, Professor of Philosophy and Ethics of Information), Scott Hale (Data Scientist), Vili Lehdonvirta (DPhil Programme Director, Research Fellow), Michael Osborne (Associate Professor in Machine Learning), Mariarosaria Taddeo (Researcher, Information and Computer Ethics), John Tasioulas (Professor of Politics, Philosophy and Law, King's College London), Greg Taylor (Research Fellow, Microeconomics of Internet mediated marketplaces), Taha Yasseri (Research Fellow, Computational Social Science). We like to note that neither the OII nor any of the above named persons are responsible for the views expressed in this report.



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INTRODUCTION

Two simple explanations

The idea that an artificial brain could compete with that of humans has been around for many years. In 2016, it's exactly sixty years ago that computer scientist John McCarthy suggested to work on Artificial Intelligence (AI) with ten men for two summer months on the campus of Dartmouth College. And now there's this excitement in the market: after decades of working on concepts, the tools are finally ready to realize that vision. We are developing new cognitive systems, self-learning computers, computers that can speak in human language and get to know us better than anyone or anything else.

This new wave of automation is cause for numerous speculations about our future. Many science fiction classics are based on this theme. For instance, Arthur C. Clarke's "Dial F for Frankenstein" from 1964, in which the telephone is born as a little baby, and as it becomes more intelligent, it starts to dominate our society. Among others, Elon Musk, Bill Gates and Stephen Hawking warn for such effects of "true AI". But man's relationship with machines can also be very warm and affectionate. A startling example: the recent success of Microsoft's chatbot Little Bing. Millions of people in China confide their deepest secrets to this machine.

It is no coincidence that we are now putting this old issue high on the IT agenda. There are two simple explanations. First of all, there is a breakthrough in the field of hardware. Watson, who beat the two champions of the TV game *Jeopardy*, has since shrunk from room-filling to the size of a pizza box. And today we're talking about creating a super brain that fits into the smartphone. This remarkably high computing power means that the concepts from the past will now shape the future.

The second explanation for the excitement has to do with the amount of data. Only ten years ago we started to move to the proverbial second half of the chessboard.¹ This is the metaphor that Andrew McAfee uses in his book *The Second Machine Age*, to explain that data has been growing exponentially since 2006. That is crucial, because Big Data is the sine qua non for the artificial brain. Therefore, the self-learning capabilities of intelligent machines (machine learning) were only able to start developing in the last few years. Machine Intelligence (MI) is the term to use nowadays. With an impending breakthrough of MI, the interesting question is which changes that will bring. In four reports on MI we will explore the potential impact. The main signal is that information technology will conquer new territories. Besides the routine tasks, the non-routine tasks are now getting automated.

1 Second half of the chessboard: <http://www.33rdsquare.com/2015/01/andrew-mcafee-on-second-half-of.html>

DEGREES OF FREEDOM, A NEW HUNTING GROUND

Increasingly sophisticated *cognitive* and *manual* tasks come within the range of automation. The scope is demonstrated by two good examples of machine intelligence. At the 2015 Hannover Messe, a robot was presented which serves a perfect "Crab Bisque". The recipe is courtesy of Tim Anderson, the 2011 winner of MasterChef UK. The robot did Anderson's job in half an hour and the taste did not differ from what Anderson puts on the table. Cooking this meal may still be difficult, but upon closer inspection it is surprisingly easy to automate.



Behind the scenes of machine intelligence: robot Moley who competes with MasterChef UK.

The company behind the Robot is called Moley. It is planning to conquer the market in 2017 with a library of 2,000 recipes and the price of the robot is approximately \$15,000. The second example

comes from IBM. Would you rather stir the pot yourself but still use robots to support you? Then you go to IBM's cognitive cooking website. Watson will make a unique recipe of ingredients you have at hand.

“Never before seen flavor combinations await you.”

Flavor combinations are not the only new thing; knowledge combinations also await you. Computers can manage increasingly more challenges, as long as they are repeatable and/or explainable. PR2, a European “cognition-enabled service bot”, taught itself to bake a pizza by watching YouTube films and consulting the right WikiHow pages. It is hardly a surprise that this project, which began in 2012, is named “RoboHow”.²

Peter Norvig, co-author of the reference work about AI – *Artificial Intelligence: A Modern Approach* – aptly describes what this transformation requires of the discipline. The AI tools can now handle probabilistic problems. Learning systems that can simply be fed with data and know how to deal with unforeseen circumstances is what it is all about these days. Norvig emphasized the importance of this transformation in an interview he gave us.

We teach computers how to learn. The result of that learning process is an answer or an action, but learning computers also give answer probabilities. They can be wrong, because there are degrees of freedom and



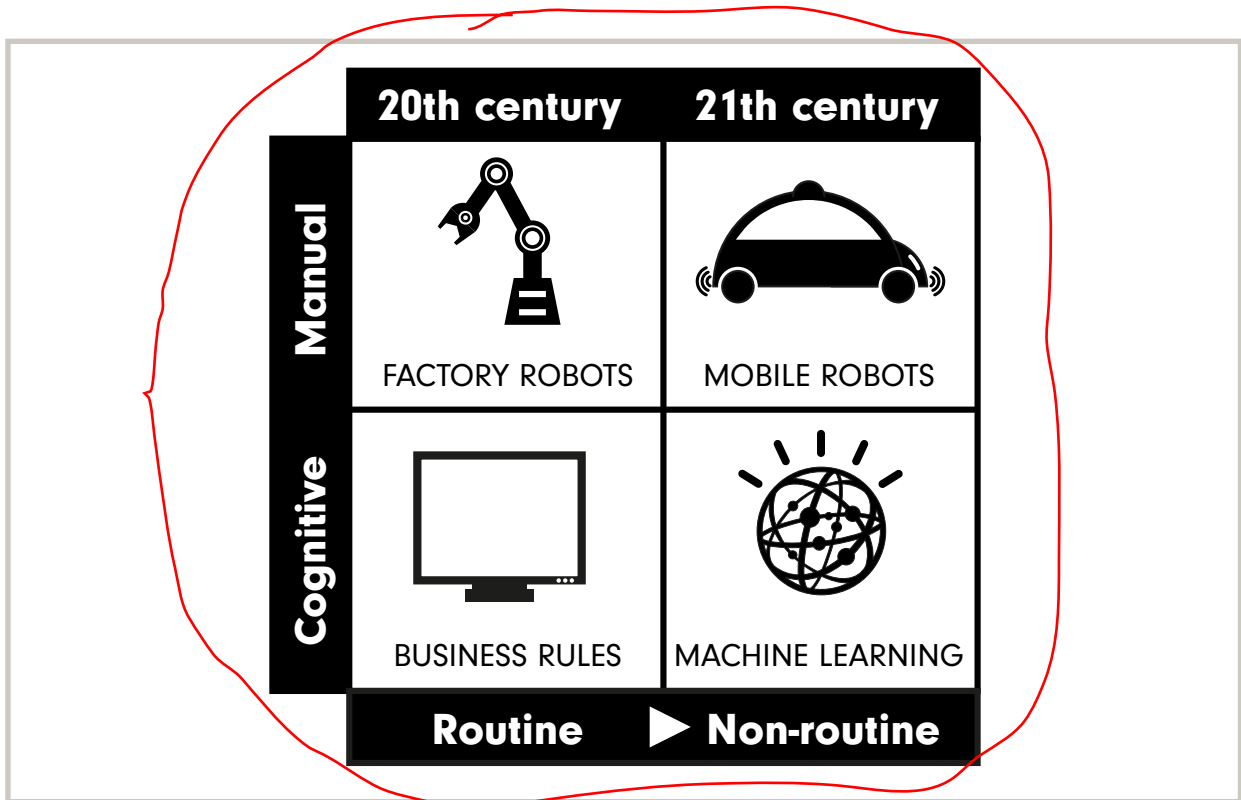
Tools of AI: veteran Peter Norvig about the current generation of learning systems.³

2 <http://www.cbc.ca/news/trending/robot-learns-to-cook-pizza-pancakes-using-wikihow-youtube-1.3204724>

3 <https://vimeo.com/48195434>

margins. The self-driving car pulls the brake because it thinks that this is the best option, and the robotic doctor gives advice based on likelihood. They do this to the best of

their ability and they keep on improving these skills. This is a major change of direction. The old computer logic is all about real routine tasks, such as checking last



“Seminal work by Autor, et al. (2003), distinguishes between cognitive and manual tasks on the one hand, and routine and non-routine tasks on the other. While the computer substitution for both cognitive and manual routine tasks is evident, non-routine tasks involve everything from legal writing, truck driving and medical diagnoses, to persuading and selling. We argue that legal writing and truck driving will soon be automated, while persuading, for instance, will not. Drawing upon recent developments in Engineering Sciences, and in particular advances in the fields of Machine Learning, including Data Mining, Machine Vision, Computational Statistics and other sub-fields of Artificial Intelligence, as well as Machine Reasoning, we derive additional dimensions required to understand the susceptibility of jobs to computerisation.”

Frey & Osborne, 2013: “The Future of Employment: How Susceptible Are Jobs to Computerisation?”

month's revenue or looking up which hospital beds are vacant. It used to be just a matter of "yes" or "no".

Breaking new ground

Michael Osborne, assistant professor Machine Learning at Oxford University, researched it.⁴ Osborne was one of the pioneers of the Oxford Machine Learning Research Group, a subgroup of the Robotics Research Group. In that capacity, his working paper "The Future of Employment" received a lot of media attention. His most important conclusion is that automation is breaking new ground with what he calls "non-routine" tasks which traditionally did not belong to the 3D-categories Dull, Dirty & Dangerous, e.g. answering questions on the telephone. Incidentally, this is indeed to be traced back to a couple of scenarios with decision trees. However, it is clearly about tasks with more degrees of freedom than turning a screw or spraying a car chassis. It is applicable to areas where *machine learning* and *mobile*

robotics must be used due to the degrees of freedom.

The Oxford study listed 702 professions and calculated the extent to which they were further "computerizable". The telemarketer tops the list, the referee and other sport officials are number 18, the 33rd position is reserved for fashion models, and the cab driver can be found at number 171. It is clear that it concerns tasks in which perception and assessment play important roles, although modeling, driving a cab or a referee's job may be done on autopilot. It can go wrong, because there are degrees of freedom. Machine Learning and mobile robotics (which also use new learning technologies) are becoming more sophisticated. This gradual process has been going on for quite some time. Referees already work with digital assistants, call centers use voice-response systems and some cars can already park automatically. The question is: what will come next? And which new human-machine balance occurs then? What choices do we make?

**Only a
human**

**Intelligent
machine
and humans
together**

**Only an
intelligent
machine**

At the end of 2014, the American business magazine Forbes stated: “Deep Learning and Machine Intelligence Will Eat the World”. You may, of course, choose not to believe everything that is written in Forbes, but in February 2015 Microsoft Azure Machine Learning was launched, followed by Amazon Machine Learning only two months later. You can get it on the web as a cloud extension of your sense&respond Business Intelligence (BI) and your shape&anticipate Business Analytics (BA). Permanent Big Data Analytics is now within reach.⁵



Brain-inspired neuromorphical chips will find their way to robots and smartphones, and enable super intelligence.

In the summer of 2015, IBM presented a computer that featured 48 million neuromorphic chips that were meant as the basic ingredients of the biological brain. The computer is suitable for deep learning and fast pattern recognition, using

extremely little electricity.⁶ These kinds of development must bring Machine Intelligence to smartphones and smartwatches.

Mr Abdel Labbi heads the cognitive systems project at IBM Research in

⁵ For a detailed analysis of Big Data, please read our four reports: *Creating Clarity with Big Data*; *Predicting Behavior with Big Data*; *Privacy, Technology and the Law*; *Your Big Data Potential*. These reports can be downloaded here: labs.sogeti.com/downloads

⁶ <http://www.wired.com/2015/08/ibms-rodent-brain-chip-make-phones-hyper-smart/>

Zurich, Switzerland. He is convinced that the Next Big Thing promise can now be fulfilled at last. The Jeopardy winning Watson-computer used to fill an entire room, but it now fits into a pizza box and it will soon fit into a telephone. The legendary John Cage of Sun Microsystems already said it over thirty years ago: "The Network Is the Computer." Now that we can count on such power on both sides – and with the comeback of the thick client – we only have to ask ourselves what the definitions of the word "intelligence" and "machine" actually are. Intel puts billions of dollars in takeovers (Indisys, Xtremeinsights, Altera) to create chips with embedded super intelligence. Algorithms based on the human brain using "associative memory" techniques will flood the market soon. Is it IBM's neuromorphic chip? Or the new Nvidia Deep Learning GPU (Graphic Processor Unit) that will be released next year and features 17 billion transistors? Or the FGPAs (Field-Programmable Gate Arrays) under development at companies such as Microsoft and Google? Eric Chung, researcher at Microsoft, describes this latest technique as a potential game changer for Deep Learning. Prototypes show a tenfold improvement of the neural network's capacity thanks to FGPA.

"We see an opportunity to apply cognitive computing not only to high-powered servers crunching enterprise data, but also to new consumer devices that need to see, sense, and interpret complex information in real time."

Josh Walden
Intel New Technology Group Senior VP

Microsoft and Amazon confirm a remarkable trend, which had already been initiated by Google Prediction API and BigML (Machine Learning for Everyone). Bill Gates already knew it for a while. *"A breakthrough in Machine Learning would be worth ten Microsofts."* he said a couple of years ago. Or maybe you would rather hear it from John Hennessy, President of Stanford University: *"Machine Learning is the hot new thing."*

We immediately have to address a few key questions here, namely: what is Machine Learning (ML) precisely? What is already possible and what is (still) fantasy? And what is causing a fuss at this moment, even though it has actually promised to supply us with serious business applications for six decades? You would like to have the answers available, even if the main purpose would just be to speak to ML salesmen. More questions will come up while you are reading this report. There is not a pat answer to all questions, but hopefully you will feel inclined to do more with Machine Intelligence after reading this report.

Amazon says: just use a free trial version of the new possibilities for one year. Knowledge of statistics, data analytics or Artificial Intelligence is unnecessary, and nowadays one single programmer should be able to achieve the same result within 20 minutes which would have lasted 45 working days in the past. You will pay only \$0.42 per computer hour plus a dime for every hundred predictions.

A real bargain! If only you had known this earlier, because overly expensive data scientists are apparently no longer needed. Oh, would you prefer a super computer based solution? In that case IBM offers all kinds of new Watson services. Thanks to the continuous development of Quantum Computing things will all astonishingly accelerate.

Luckily, in reality, you have missed nothing. These types of accessible data services are in fact completely new. The label we put on this new trend is Machine Intelligence (see section 4 of this report). This unifying term finds favor with both the "true AI" school and the pragmatic learning minded.

The essence of Machine Learning and similar concepts, such as Deep Learning and pattern recognition, is that the computer learns from experience. This is called Artificial Intelligence or "true AI" if the objective is to let computers emulate human intelligence. According to some, there are boundless other possibilities. The AI

Machine Intelligence

"MI is a unifying term for what others call Machine Learning (ML) and Artificial Intelligence (AI). When I called it AI, too many people were distracted by whether certain companies were 'true AI,' and when I called it ML, many thought I wasn't doing justice to the more 'AI-esque' like the various flavors of Deep Learning."

domains are on a scale of Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI) and Artificial Super Intelligence (ASI). Another term is "weak-strong-super AI", in which the true variant stands for strong.

In "Probabilistic Machine Learning and Artificial Intelligence", published in *Nature* in May 2015, you can read about the contributions of learning machines. The theme of the article by Professor Zoubin Ghahramani, head of the

Cambridge Machine Learning Group, is: *"How can a machine learn from experience? Probabilistic modelling provides a framework for understanding what learning is and [...] has a central role in scientific data analysis, Machine Learning, robotics, cognitive science and Artificial Intelligence."* Lian Huang, professor at the City University of New York, says that it actually differs very little from automating automation and that it best to think of yourself as a gardener if you want to make progress:

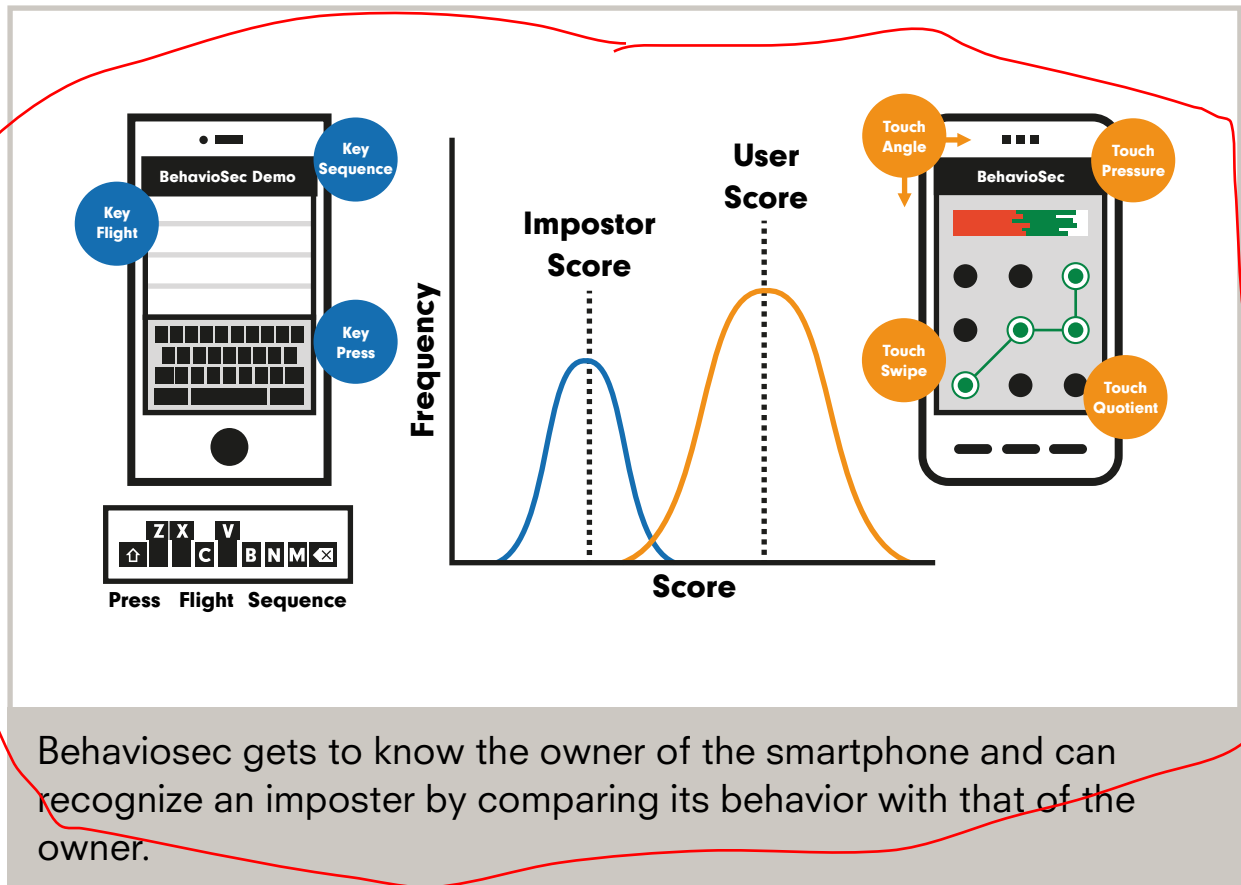
Machine Learning

"Machine Learning is Automating Automation. It is about getting computers to program themselves: letting the data do the work instead. That's no magic but more like gardening: think of algorithms as the seeds; of data as nutrients; of yourself as the gardener; and of programs as the plants."

Photo devices recognize the faces they need to focus on thanks to machine learning, and chess computers win the game thanks to machine learning. You even now know whether it will rain in your garden five minutes from now thanks to Machine Learning. The process from speed camera to receiving a fine also takes place thanks to machine learning. In short, intelligent devices are already present in many places and they are important business tools.

Microsoft, IBM and Amazon now do a little extra by delivering

Machine Intelligence which makes it possible for you to tap into the cloud market. Machine Intelligence will also be included on new smartphones, ensuring more computer safety, for example Bahaviosec. This Swedish company which is listed on the Europe 100 Hottest Startups has the following slogan: *"Your behavior as an extra layer of security"*. How hard the keys are being pressed, the speed or power with which the smartphone screen is being touched, are all validated via machine learning and form your personal signature.



This provides additional security, but it does not come at the expense of the ease of use. We have known how convenient apps are for a number of years, but “cogs” can make our lives even simpler by adding intelligence.

STATE OF THE ART MACHINE INTELLIGENCE

“AI for All” is the motto. If there is something striking about the state machine intelligence nowadays, it is the ambition to scale every kind of machine intelligence scale as soon as possible. Anyone can use the new tools, which is mainly due to the cloud. Startups demonstrate plug-and-play applications in their pitches and large companies provide their services all through the cloud. Not only venture capital providers are enthusiastic. Also, Kevin Kelly, founder of the famous Wired magazine, is very optimistic. His prediction:

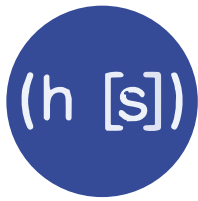
“The business plans of the next 10,000 startups are easy to forecast: take X and add AI.”

The ambitions of new players are clear. Scalability is even more important than intelligence. Investors are interested in plug-and-play solutions; the world needs to be conquered quickly. Wit.ai (bought by Facebook at the beginning of 2015) and HyperScience are exemplary. The former has developed an API for Internet of Things products, and the latter has automated the data scientist. It is often mentioned in the context of Machine Intelligence that this scalability may help solve the shortage of data scientists.



Wit.ai

Wit.ai is an API that makes it very easy for developers to create applications or devices that you can talk to. Any app, or any device, like a smart watch, Google Glass, Nest, even a car, can stream audio to the Wit API, and get actionable data in return.



HyperScience

Most databases can only tell you about the past. HyperScience can tell you about the future. The company built an automated data scientist that is easy to use and requires no data science, statistics or distributed computing expertise. It is self-configuring, self-tuning and self-healing. It scales horizontally and supports real time queries.

The investments in Machine Intelligence startups tripled in 2014⁷ and research by Deloitte predicts that the total market for machine intelligence will grow from \$1 billion to \$50 billion in the next three

years.⁸ IBM invested one billion in a division around their own Watson technology. IBM also bought the company Merge Healthcare for another \$1 billion in order to supply Watson's medical services with billions of images of MRIs, CT scans and X rays. Google bought DeepMind for an estimated \$500 million and is quickly taking over many robot companies, such as Schaft, Industrial Perception, Redwood Robotics, Meka Robotics, Holomini, Bot & Dolly and Boston Dynamics. Facebooks opens AI labs on different continents and invests a lot of money in research. Salesforce buys Relate1IQ; Microsoft pays \$200 million for Equivio; Twitter buys Madbits. Palantir, Peter Thiel's company against fraud and counter-terrorism, is estimated at \$20 billion after a \$450 million capital injection; it entered the Top 5 of *The Wall Street Journal's* Billion Dollar Startup Club in July 2015. More early take-overs (so-called early exits) of startups by parties such as Facebook, Google and Baidu are to be expected, mainly as a result of the necessity of small players to feed their algorithms with Big Data in order to improve faster.⁹

7 "Artificial Intelligence startups see 302% funding jump in 2014", <https://www.cbinsights.com/blog/artificial-intelligence-venture-capital-2014/>

8 "Learning from Machine Intelligence, The Next Wave of Digital Transformation", Orange Institute

9 "AI Investment, Arbitrage or Aberration: Can VCs generate outsized returns from pure play AI startups?", <https://medium.com/@mattwiczrowski/ai-investment-arbitrage-or-aberration-c74511413865>

Baidu's pursuit for hundreds of millions customers

The Chinese company Baidu with a market value of over \$70 billion goes "directly for the bottom line", as they call it, with Deep Learning. Baidu wants to serve hundreds of millions customers directly with AskADoctor. IBM focuses on doctors with Watson, but AskADoctor focuses on consumers. You just get your smartphone, mention the symptoms and AskADoctor gives a diagnosis with an accuracy of 75 percent. This "cog" contacts specialists in the area, with the intention of speeding up the usually time-consuming, long-winded process of finding the correct specialist in China. Andrew Ng has set up the Google Brain project at Google and founded the online learning platform Coursera. Andrew now is in charge of Baidu's deep learning team. His ambition is to create a medical robot as soon as possible.

Robot apps for faster growth

The cloud needs to enable robots to help make the human world better. The cloud can become an overall brain in a "World Wide Web for Robots", in which robots upload

their experiences. Other robots will then be able to download these experiences, learn from them and apply them in their own surroundings. The robotic vacuum cleaner is a good example. As soon as these devices encounter an unknown object, they don't know what to do. However, if only they would send a picture to the cloud asking what it might be, other robots or humans could supply them with an answer. Robot platforms featuring app stores for robot tasks are a logical continuation of what is happening with smartphones in recent years. There is general consensus that this will succeed. At the 2010 Humanoid Robotics conference, former robotics professor James J. Kuffner, currently researcher at Google, was the first person to address this issue:

"A new approach to robotics that takes advantage of the Internet as a resource for massively parallel computation and sharing of vast data resources."

The cloud and robot app stores will be able to spread this kind of intelligence faster. For the time being, the app stores for robots are filled with gadgets. Robotappstore.com has, for example, applications for popular robots such as the Aibo (dog) and the Roomba (vacuum cleaner) to let them create music or allow them to dance. Interesting but not the long-anticipated kind of intelligence we are waiting for.

There are 2,948 investors in 423 new Machine Intelligence organizations. An updated list of names of these investors and the companies they invest in can be found on this webpage: <https://angel.co/artificial-intelligence>. The companies are divided into the following categories: Algorithms, Computer Vision, Image Recognition, Machine Learning, Natural Language processing, Semantic Web, Speech Recognition and Intelligent Systems.

A similar division can be found on the website of Venture Scanner.¹⁰ The list on that particular website features 855 companies with a total funding of \$2.73 billion. A special category has been created for Virtual Personal Assistants. It includes 71 companies, such as the well-known Siri, but also MedWhat which answers questions about your health, and Aivo which produces “agentbots” for handling customer questions. Venture capital investors are very enthusiastic. Kevin Kelly, founder of the famous magazine *Wired*, also has a very good feeling about it. He predicts that the following will happen:¹¹

“The business plans of the next 10,000 startups are easy to forecast: take X and add AI.”

Kevin Kelly
Founder *Wired* Magazine

10 “Making sense of the Artificial Intelligence Ecosystem”, <http://insights.venturescanner.com/category/artificial-intelligence-2/>

11 “The Three Breakthroughs That Have Finally Unleashed AI on the World”, http://www.wired.com/2014/10/future-of-artificial-intelligence/?mbid=social_fb

THE MACHINE INTELLIGENCE LANDSCAPE

The first edition of the standard textbook *Artificial Intelligence: A Modern Approach* was published twenty years ago, following four decades of AI research. It brought a dozen or so barely related subfields together in a coherent framework, according to the authors. Professor Stuart Russell and Peter Norvig explain what this modern approach means in the preface:

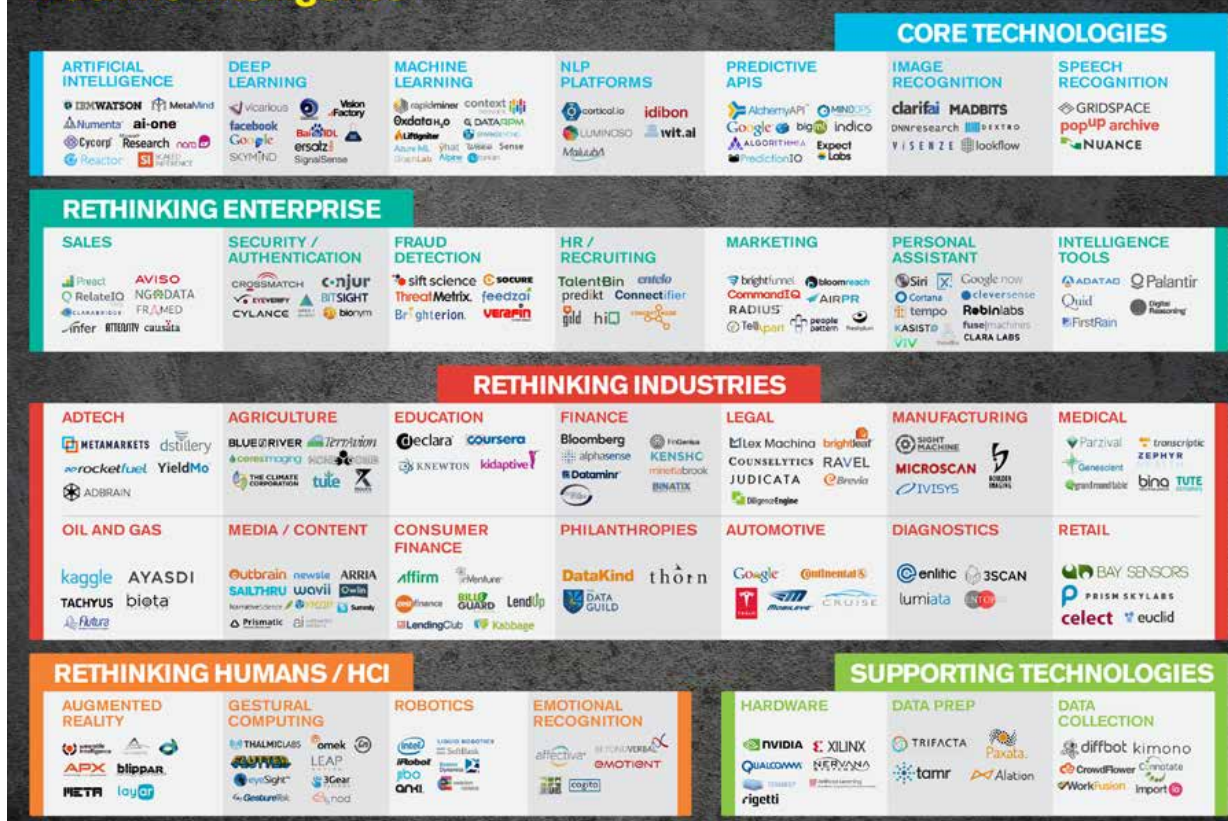
“The intended meaning of this rather empty phrase is that we have tried to synthesize what is now known into a common framework, rather than trying to explain each subfield of AI in its own historical context”.

Shivon Zilis, venture capital investor at Bloomberg Beta, noticed exactly the same in 2015 when she was planning to map the state of affairs regarding areas, companies and products. She found that the best umbrella term today is Machine Intelligence (MI) rather than AI. Ms. Zilis’s overview contains an extensive list of approximately 240 companies and labels under the 35 labels that together form the converging field of Machine Intelligence. Converging is an understatement – it is beyond dispute that Personal Assistants (Cortana, Siri, Google

Now, Viv, M, etc.) might as well be listed in the category Rethinking Humans (HCI). However, nowadays Personal Assistants have very specific applications and they have indeed been through the original technology phase.

Venture investors are beginning to turn their backs on Big Data. They are now particularly interested in verticals, the specific translation of Big Data. The synthesis therefore: look at the concrete business applications: “rethinking industries, rethinking organizations”.

Machine Intelligence LANDSCAPE



240 Machine Intelligence organizations in 5 domains and divided in 35 categories (www.shivonzilis.com)

You may ask whether companies can make this “rethinking” promise reality. In that respect, it is interesting to follow what Shivon Zilis says about its categorization:

1. Initially, “There’s a hell of a lot going on in MI.” We see this also reflected in this landscape (and this is just one snapshot).
2. The second point is that many of these products really work. In her presentation “New business models in Machine Intelligence” Zilis shows a day in her life, and how she uses Machine Intelligence tools.
3. Then we get to the third conclusion of this framework: the productivity of the knowledge worker will benefit. That connects logically to a fourth conclusion:
4. The success of Machine Intelligence is determined by Human-Machine Interaction (HMI).

Rethinking

It's all about rethinking, or reinvention. One of the startups under the umbrella of "Rethinking Oil & Gas" is Tachyus. This company is a nice example of a vertical that makes clear which way things are heading: supporting the knowledge worker and directly contributing to the top-line growth. Tachyus offers the industry a machine learning solution that can increase the production capacity of oil sources by 20-30%. The learning model had been six years in the making, in cooperation with a number of small operators of oil and sources. Tachyus does not just focus on how the production of existing sources may increase, but it also identifies the best locations for new drillings. This machine learning tool offers a so-called Rethinking-as-a-Service, basically as a practical accelerator of the process. Or let's look at MetaMind. This company is mentioned in the top left corner of the landscape. It was founded with money from Salesforce.com and Khosla Ventures. CEO David Socher has created a user friendly drag-and-drop application which makes it possible to start immediately. Image and text patterns are recognized and will be converted into useful analyzes. MetaMind may be listed as an AI company, but it is a partner of the company Caresharing and is now capable of diagnosing diabetic retinopathy. This approach could be labelled as

"Rethinking Medical", also because MetaMind collaborates with vRad to analyze strokes. This implies that easily applicable AI tools can quickly reach a certain vertical.

The Machine Intelligence open- source landscape

We see a large number of startups in the Bloomberg Beta landscape. However, there is also another landscape: the open source toolbox. It offers countless possibilities and requires more personal development. GitHub is an excellent source for this. The bad news is that many barely related subfields are presented, bringing us back to Russell and Norvig's point. GitHub can be compared to a collection of garages, and Bloomberg Beta's division is like a shining motor show. GitHub features a tool for dynamic pricing, for instance, which was recently made available by Airbnb. But it is listed under the bland heading "A machine learning package made for humans" and it is called Aerosolve. Recently Google released TensorFlow it's machine learning platform, which created a lot of excitement among the techies.



Intel published Stephen Hawking's communication software on GitHub in August 2015. The system's Artificial Intelligence was a direct cause for his concern: "Thinking machines are a threat for humanity."

We suggest the following layered model as a framework for the state of the art; you can also read it upside down or you can imagine it as circles. The new drivers of the entire MI field are the many new supporting technologies. The core technologies are the proven supporters of AI. Many fundamental and practical developments are taking place at this very moment,

such as adding both pattern recognizing and machine learning. These devices traditionally focus on Human-Computer Interaction and Human-Machine Interaction. Ground-breaking current developments in the field of AI and MI have led to many concrete Rethinking applications that focus on verticals and business.

Machine Intelligence

Supporting Technologies

Hardware, Data Prep, Data Collection

Core Technologies

Artificial Intelligence, Deep Learning, Machine Learning, NLP Platforms, Predictive API's, Image Recognition, Speech Recognition

Rethinking Humans/HCI/HMI

Augmented Reality, Gestural Computing, Robotics, Emotional Recognition

Rethinking Enterprise

Sales, Security/Authentication, Fraud Detection, HR/Recruiting, Marketing, Personal Assistant, Intelligence Tools

Rethinking Industries

Adtech, Agriculture, Education, Finance, Legal, Manufacturing, Medical, Oil and Gas, Media/Content, Consumer Finance, Philanthropies, Automotive, Diagnostics, Retail

Norvig describes the new era strikingly; the comedy series *Little Britain* depicts the old era equally well. From a twenty-first century perspective, it is an almost unrecognizable caricature of computer logic and expert systems in the previous century. You type a text and an answer follows. No discussion, but lots of frustration instead.

The sketches are always about a customer at a counter, and the counter clerk always answers "Computer says no". The failure of Human-Computer Interaction (HCI) is demonstrated by the anger that follows. The same HCI factor determines the success of modern learning systems, from Google Car to the digital assistant. Reading the bestseller of Nobel Prize winner Daniel Kahneman,¹² you begin to understand what kind of tasks computers can do better than men. Kahneman describes many examples of human failure in his best-seller. Humans often base their decisions on the information at hand; they allow themselves to be misled by this defect. Kahneman describes this phenomenon as "What You See Is All There Is" (WYSIATI). Computers are not affected to the same extent as humans. Do you want to get a quick impression of human errors of judgement? Look at this list of more than 200 of such cases on the Wikipedia entry on cognitive bias: https://en.wikipedia.org/wiki/List_of_cognitive_biases

In his book *Thinking Fast and Slow*, Kahneman distinguishes the intuitive and the calculating brain. The former works fast, the latter slowly. They cooperate; sometimes we use one of them more than the other, and they influence each other. Kahneman painfully makes clear what this can lead to in an example in his book:

The decision-making process of eight Israeli judges was examined. Their daily work consists of determining whether prisoners are eligible for early release. On average, it took the judges 6 minutes to reach that decision and only 35% of the requests is accepted. However, 65% of the requests was approved following a coffee or lunch break. The percentage slowly dropped and reached zero until the next break. The explanation: system 2 uses more energy, also literally. In such cases people depend on the intuitive system, which costs less energy.



Little Britain character Carol Beer in a typical “computer says no” sketch. She’s serving clients at her desk, invariably the question, the answer is no. It is in these type of situations we desire more friendly autonomous robots to replace humans

The ingrained prejudices and syndromes form fertile soil for machine intelligence. Herbert Simon, one of the founders of the AI discipline, has a logical explanation for these prejudices. We cannot keep on weighing our options all day long; people have more things on their mind. We simply choose the best solution, based on the time we wish to spend on it. Simon calls this process “satisficing” and the people “satisficers”. Shortcuts are useful methods to make a decision.

In such cases computers can be useful additions when people fail. They do not suffer from NIH (Not-Invented-Here) and WYSIATI in our “All There Is, Is What You See” era of Big Data.

Steve Abrams, head of IBM’s Watson Life project, regards creativity as the crowning glory of human intelligence. IBM wants to learn how our creative brain works in order to make more intelligent machines.

“One of the biggest pieces of understanding how people work is uncovering what it means to think creatively.”

Steve Abrams, director Software Technology Research IBM

The cognitive cooking project also taught IBM about interesting limitations. Watson, for example, created a special flavor combination of olive oil and apple, but real-life cooks at first did not like this at all. The reason for this reluctant approach is called confirmation bias: when people try to solve problems, they often look for information that supports their existing ideas and they overlook other options. Lack of knowledge may also get in the way. We tend to choose familiar things, and the overfamiliar Not-Invented-Here (NIH) syndrome causes people to be more critical of other people's ideas and less critical of their own. Abrams mentions these three specific examples – confirmation bias, ambiguity effect and the Not-Invented-Here syndrome. Add the WYSIATI of Daniel Kahneman to those three, and you begin to see the areas where machine learning can be of great value.



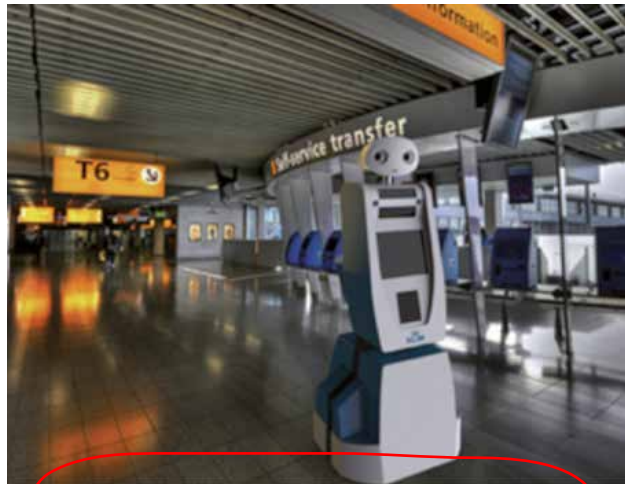
THE NEXT BIG THING AND THE INEVITABLE SURPRISES

At the end of the 80s, the American DARPA (Defense Advanced Research Projects Agency) thought differently about AI. After decennia of investments, DARPA suddenly stopped financing AI, stating “This is not the next best thing”. The following era is known as the second AI winter. The first winter period lasted from 1974 to 1980.

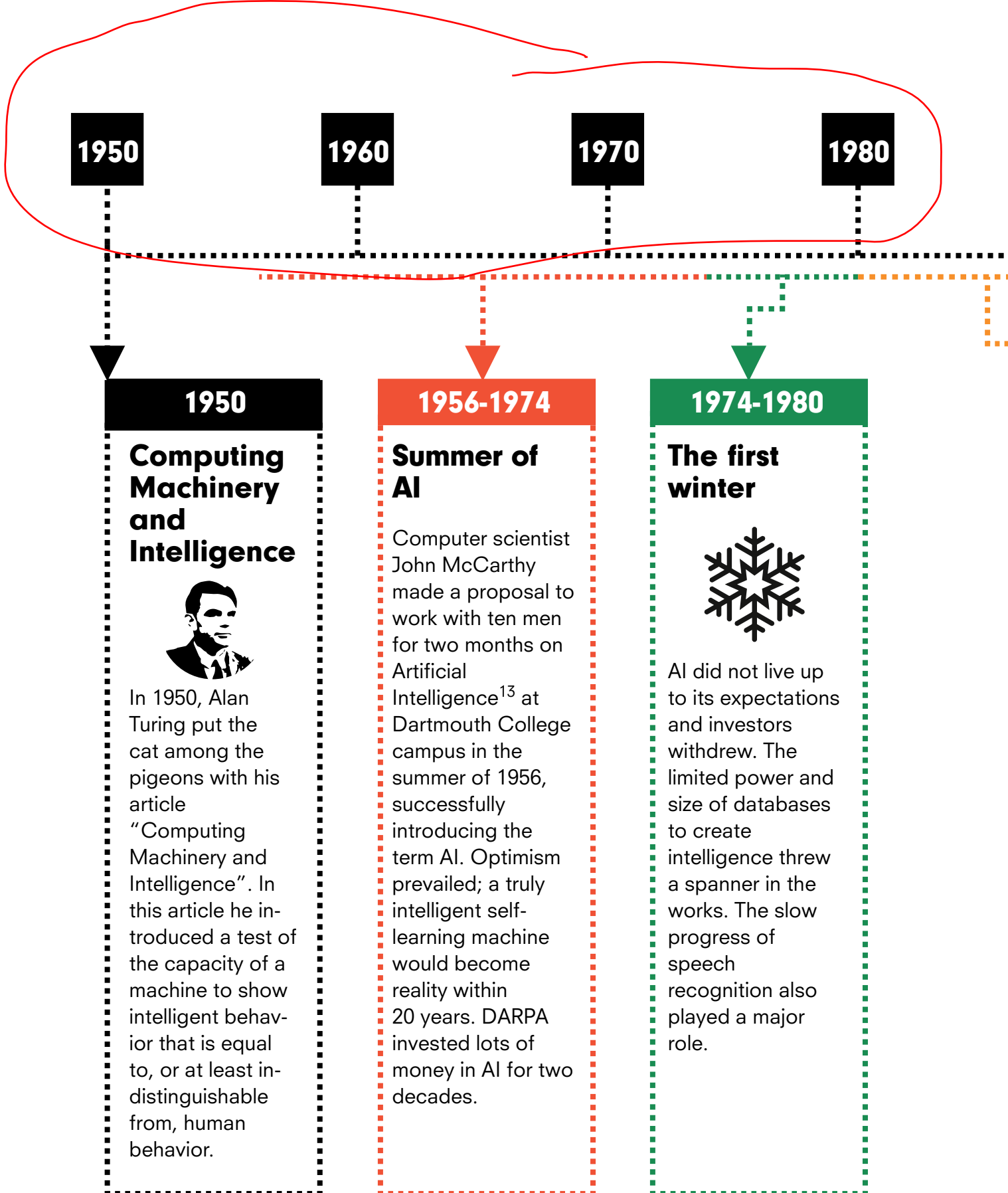
It all started very positively in the fifties. Artificial Intelligence in its strongest form would be within reach: machines were to become just as intelligent as humans. But there were limitations: intelligence needs a lot of working capacity and it longs for data. It all ended with the Symbolics 3640 LISP machines. The history (and future) of machine intelligence software is largely determined by hardware.

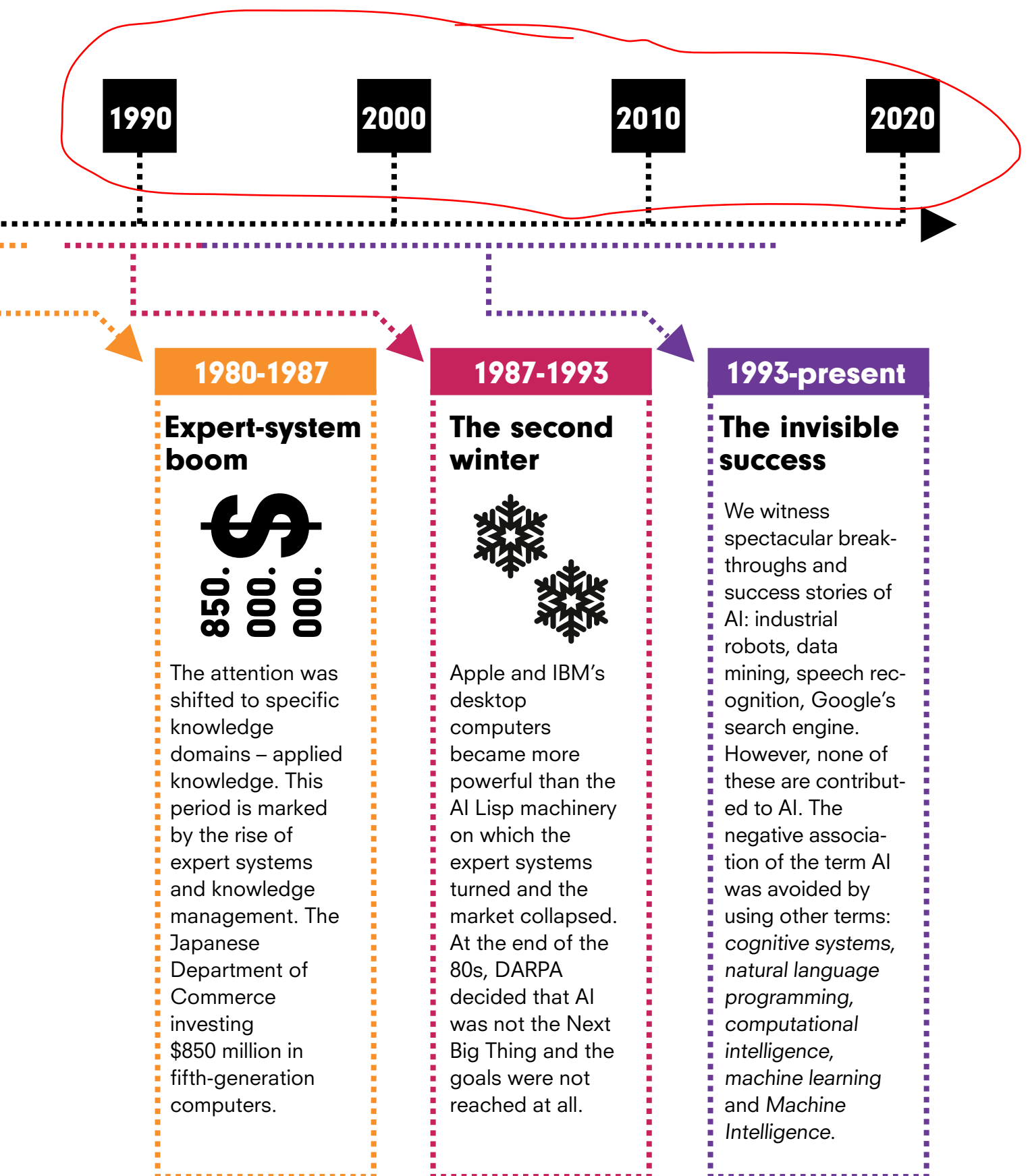
DARPA is now back to invest another \$53.5 million in a brain computer that is being developed by IBM. The future looks sunny again. But what happens when proof of concepts hit reality? It is interesting to see that KLM Royal Dutch Airlines plans to use intelligent machines in new non-routine situations on Amsterdam Schiphol Airport. But how will this turn out? The airport has worked together with six universities to develop Spencer, a social robot. Spencer’s task is to help transfer passengers find their way from and to the gate. This is called “smart passenger flow management” in airport jargon.

On Schiphol Airport 70 percent of KLM passengers are in transit. Travelers miss their connecting flights on a daily basis due to delays, narrow transfer times, difficulties finding the way and language barriers. KLM wants to manage these problems better with the help of Spencer; this robot will leave the lab in 2016 to begin his life



Robot Spencer at Schiphol airport is helping passengers to find their way, and speaks different languages, like Chinese.







at the airport. However, it is uncertain whether it will become a success. Spencer has a little brother in Japan, Robovie II, who drives around the center to help people doing groceries. The life of this shop robot is often made miserable. Children frequently block his way or, even worse, kick and beat him. Researchers of Japanese universities have interviewed children who bothered the robot for the report *Why do children abuse robots?* In response to the question whether they considered the robot “machine-like” or “human-like”, 74% chose human-like and 13% machine-like. Nevertheless, they continued harassing the robot, probably out of curiosity.

The molestation of another robot made worldwide headlines on 1 August 2015. The famous hitchBOT was found on the side of the road in Philadelphia, hacked to pieces. The robot had been developed by two Canadian universities; it had a body, arms, legs, a head, 3G and GPS. It

was able to have a conversation. This “ideal” travel buddy went around the world as a social experiment. Its journey came to an abrupt end, after having lasted well over a year and having travelled 10,000 kilometers.

Unknown factors determine the future

So we move into new territories. Social issues, ethics, human action, safety, legislation, privacy and other matters will be just as decisive for the course of history as technology itself. Ten years ago, hardly anyone could have predicted how fast the collective addiction to smartphones would struck the world. Sometimes we make accurate predictions about technology, but we also often get it wrong. It really becomes difficult when it comes to the use of technology.

Ray Kurzweil is a good example of someone who got it right. In his 1999

book *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*, Kurzweil made a reasonably accurate prediction: he predicted that in 2010 it would be the most normal thing in the world for people to own a small, simple mobile device that could translate from spoken English to spoken Chinese in real time. However, Levy and Murnane found a mare's nest in their 2004 publication *The New Division of Labor: How Computers Are Creating the Next Job Market*. They claimed that computers would never autonomously steer cars; that would be one step too far. The authors were proven wrong; only a couple of years later, in 2010, the Toyota Prius drove up the road without a driver, steered by Google's Machine Intelligence instead.

But what will happen, for example, if people forget to purchase a "pedestrian detection module" for

their self-driving car (follow the link to view the accident: https://www.youtube.com/watch?v=_8nnhUCtcO8)? Such incidents could make autonomously driving vehicles far less popular. Or imagine that the recently released Amazon Echo becomes an enormous success. Talking to a digital avatar (that will always listen to you and respond immediately) will become just as normal as a touch screen. Intel already anticipates this development. Their new Skylake processor for Windows 10 always listens to you and you can invoke Cortana at your office at any given time. Robots will soon appear at Amsterdam Schiphol Airport, Watson doctors will join shifts with regular doctors, and we will even be able to drive down the road without touching the steering wheel. Nevertheless, it is still unknown how we are going to use all this lab technology in everyday life.

An advertisement for the Amazon Echo smart speaker. The image shows the black, cylindrical Echo device with its blue light ring at the top. To the left of the device, the text "INTRODUCING amazon echo" is displayed, with a "WATCH VIDEO" button below it. To the right of the device, the headline "ALWAYS READY, CONNECTED AND FAST. JUST ASK." is shown. Below this, a list of features includes: "Information, music, news, weather, and more—instantly", "Controlled by your voice for hands-free convenience", "Voice recognition hears you from across the room", and "Connected to the cloud so it's always getting smarter". The pricing is listed as "\$199 | \$99 Prime members save \$100 Limited time only". A "Request an invitation" button is present, followed by the text "By invitation only. Learn more".

INTRODUCING
amazon echo

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The sixtieth anniversary of AI will take place in 2016. Many things have changed since the concept of AI was first launched. Following two winter periods and too many high expectations, the situation is finally clear: anyone who wishes so can start with Machine Intelligence tomorrow. Even major players such as Amazon, Microsoft and IBM are embracing the current “AI for all” era. Big Data, machine learning and the cloud offer you the chance to make more intelligent organizational decisions. Is something still missing in your toolbox? In that case, you can simply go to GitHub and check what kind of tools Airbnb, Google and Facebook, for example, have donated in that area.

After Mobile, Big Data and the Internet of Things, Machine Intelligence is The Next Big Thing. Machine Intelligence is the accelerator of these predecessors. Especially thanks to the extremely improved hardware plus the explosion of data (the sine qua non of self-learning), we are making breakthroughs in the field of Machine Intelligence. There is good reason to greet the jubilee year – sixty years of Artificial Intelligence – with optimism. That is also reflected in the tripling of the number of startups in this field (in a year) and the huge investments made now by companies like IBM, Baidu, Salesforce, Toyota, Facebook and many others.

The practical approach to Machine Intelligence is that Amazon charges \$0.42 for one hour of Machine Learning, Microsoft Azure Machine Learning gives you immediate access to cloud intelligence and IBM now has a billion dollar division

to make your organization smarter. Airbnb’s building stones on GitHub and many others (including Google) can be added to this; the developments follow in rapid succession. And let’s not forget the annual, increasing flow of startups, which are coached by venture capitalists. These companies pitch their products in a very specific way, by focusing on particular sectors and businesses. Healthcare, industry, agriculture, advertising companies, security, so basically any sector, can all benefit from the MI framework and this will lead to serious “rethinking”. How did we use to do this in the past and what is possible today? How will computers be able to assist – or even outpace, as you please – humans even more in the coming years?

The technological possibilities that present themselves are new. The non-routine tasks, especially in the more “uncontrolled environments”, are the new IT hunting grounds.

Also, thanks to the core technologies of the Machine Intelligence landscape that we outlined to you, it is possible that computers enter these new areas. In particular, computer vision, machine learning, natural language processing and natural language generation make that computers can better support human tasks or automate them completely. Computers learn to understand ordinary human language, decipher images and talk to us in ordinary human language. Cars that recognize a pedestrian and then take appropriate action, it is just one of the amazing capabilities of modern computers. The diagnosis of a disease or providing legal advice based on all existing jurisprudence, it is just another astonishing accomplishment of Machine Intelligence. We are getting to a point where the founders of Artificial Intelligence have dreamed of for years.

We outlined the classic “Computer says no” situation of *Little Britain* as a caricature of a bad interaction between man and computer. It is in these situations that we yearn for much better man-machine interac-

tion, or better still, for all the computers to take over to deliver 24/7 friendly service, listen to our questions and always take the correct actions.

Thanks to Machine Intelligence, computers are getting better and we will see clearly which new tasks computers can take over from man. Whoever doubts the capability of the computer to compete with man in new areas, we recommend to read the standard work of Nobel laureate Daniel Kahneman, *Thinking Fast and Slow*.

But there are still plenty of doubts about the future of Machine Intelligence. We pointed you to research on children who bully robots, for instance, and referred to accidents with self-driving cars. In light of these examples, the studies on the impact on labor are quite a contrast. The figures from studies on the future of labor look terrifying. And there are many more things people fear as they are confronted with these intelligent systems. Will computers take over control? Should we call a halt to this development, and can that be done?

LOOKING AHEAD FOR TOPICS TO EXPLORE

The new working relationship, employment relationship and balance of power between man and machine is the central topic in our subsequent reports on Machine Intelligence. The interaction between man and machine (Human-Computer Interaction) will surely change: computers will learn from people and people again will learn from those computers. How that is going to work out, we will explore along the axes of human behavior, technology, organization and society. The priorities we have defined are as follows:

The Personal Digital Assistant (technology)

The development of Machine Intelligence will lead to completely different ways of dealing with information technology. Apps will then have been a transitional stage which, once passed, leads us to the much richer world of cogs. How likely is this scenario? And if that happens, what consequences are to be expected from this cog effect? If you fancy an appetizer, we refer you to a brief demonstration by deep learning guru Yann LeCun. LeCun demonstrates Facebook's version of the modern PDA, called M.



Persuasive Technologies (behavior)

An important part of the MI developments is being driven by machinery to change our behavior. This machinery is based on Persuasive Technologies, a field that is developed by the Stanford Persuasive Technology Lab, and is designed to change attitudes and behaviors of users. Knowledge of Persuasive Technologies is a decisive factor for the success of Machine

Intelligence. It can come from a robot which carries out certain care tasks or perhaps from a robot at the counter, or a call agent that causes you to purchase a product. The most advanced use of persuasive techniques we find in e-commerce: from the recommendations of books on Amazon to the personal ads on Facebook. Persuasive Technologies uses advanced personal profiling, based on Machine Intelligence. We will explore what techniques you need to master and how it works in practice. In an interview Maurits Kaptein, assistant professor AI at the Radboud University, gives a preview on an important question related to all of this. How transparent must organizations be when it comes to using these techniques?



The corporate IQ (organization)

In what areas can Machine Intelligence contribute value to your organization? And what are the steps to be taken? These are obviously important questions when it comes to calculating the ROI for Machine Intelligence. This change in the man-machine relationship is a journey of discovery. Whether it involves the use of a cognitive system by a general practitioner or the introduction of a self-driving lorry in a transport company, we don't have a lot of real life experience yet. But can you anticipate potential unexpected consequences and reactions? We will collect at least the first best practices and see if there are already lessons to be learned. An interesting warmup is a case of *The New York Times*. Their "pretty advanced machine learning tool", the friendly chatbot Blossombot, is boosting *The New York Times'* media attention.



**The
New York
Times**

Read about the success of Machine Intelligence at *The New York Times*
<http://www.niemanlab.org/2015/08/the-new-york-times-built-a-slack-bot-to-help-decide-which-stories-to-post-to-social-media>

Anatomy of fear and hope (society)

Experts warn us of the dangers of Machine Intelligence. A long list of authorities in the field of Machine Intelligence rallied recently behind a petition which warned against the use of robots in warfare. The Rathenau Institute also advocates for a global ban on these killer robots. One of the robotic laws of science fiction writer Isaac Asimov (“a robot may not kill”) has become part of a huge debate. Fear of fighting robots is just one facet, fear of job loss, loss of control and robots running society can be added to that. Anxiety, but also hope for a better world, and the question how we relate or will relate to this new technology are always in the background of the debate. What can we learn from this fear and how realistic are these fears? And are these kinds of science fiction stories relevant to the further development of Artificial Intelligence? The science fiction movie *Her*, with leading character Joaquin Phoenix, which shows that falling in love with algorithms should also be feared, already provides some inspiration.



What would be the impact of Machine Intelligence on society if the scenario from the movie *Her* were to become a reality?
https://www.youtube.com/watch?v=6QRvTv_tpw0

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