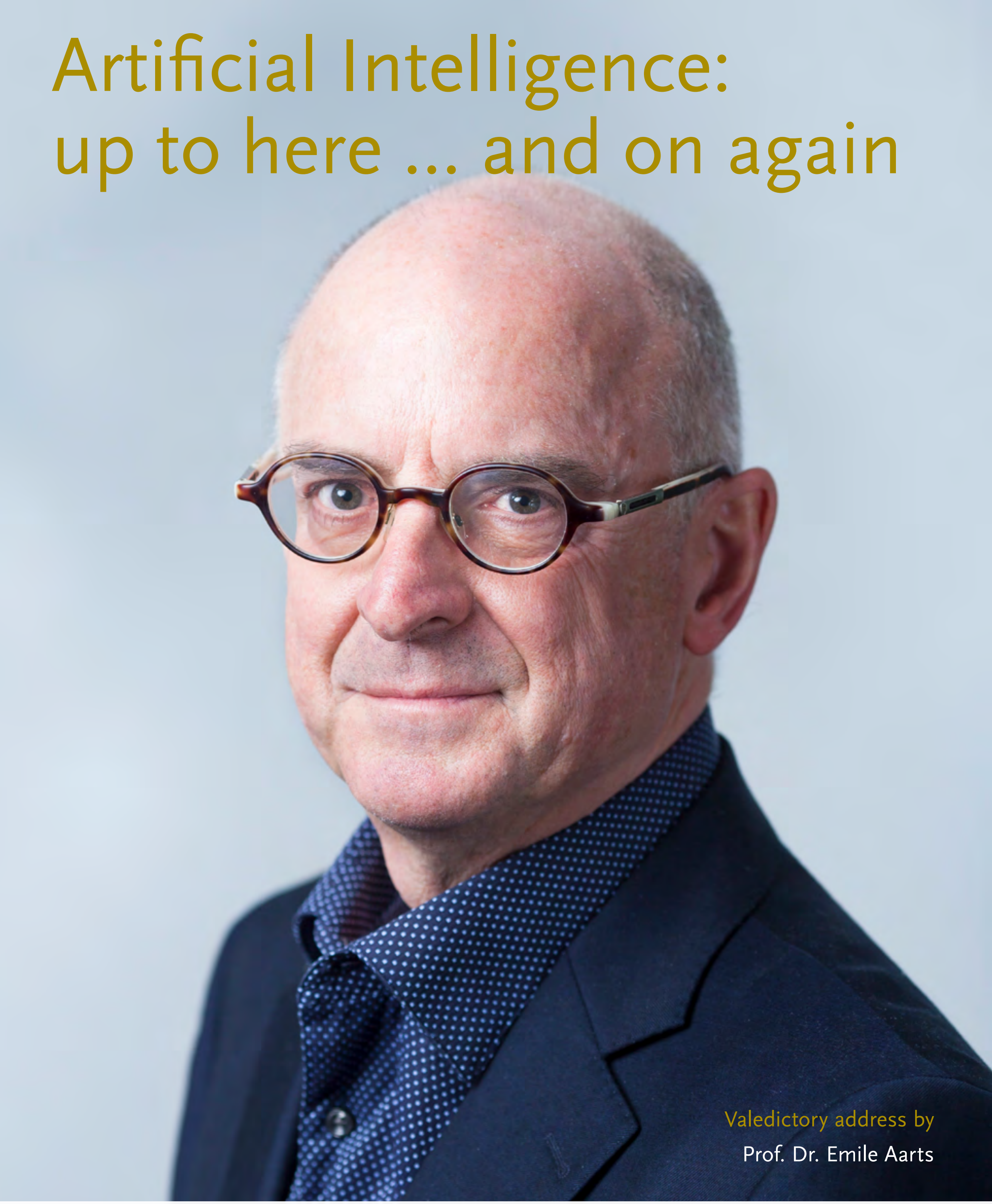
Artificial Intelligence: up to here ... and on again



Valedictory address by

Prof. Dr. Emile Aarts

Tilburg University

Understanding Society

Prof. Dr. Emile Aarts (1955) is an emeritus professor of Computer Science at Tilburg University. He holds an MSc. degree (cum Laude) and a PhD. degree in mathematics and physics from Radboud University Nijmegen and Groningen University, respectively. After completion of his academic studies, he joined Philips Research in 1983 where he worked in various research and management positions until he was appointed in 2009 as Chief Scientific Officer. In 2012 he left Philips to resume a full-time academic career as dean of the faculty of Mathematics and Computing Science of the Eindhoven University of Technology. From 2015 until 2019 he has been the rector of Tilburg University.

He is an experienced research scientist with an H-index of over 50 (Google Scholar) and over 30,000 citations (Google Scholar). He is the co-author of twenty books and more than two hundred fifty scientific papers. His most influential work is on heuristic search, a branch of mathematical optimization that has a broad application in artificial intelligence, engineering, and management sciences.

Over the years, he has launched several novel initiatives. These include the Embedded Systems Institute (TU/e, TNO), the Creative Conversion Factory (Philips), Experience Lab (Philips), the Intelligent Lighting Institute (TU/e, Philips), and the Data Science Institute (TU/e). In 2015 he co-founded the Jheronimus Academy of Data Science, as an initiative to develop a broad data science cluster in the wider Brabant Brainport region as a joint effort of Tilburg University, Eindhoven University of Technology, the municipality Den Bosch, and the province of Noord Brabant. Later initiatives are MindLabs (Spoorzone Tilburg) and the Dutch national ELSA Labs program.

He has served on numerous academic and governmental advisory boards both at national and European level, mostly with a special purpose to develop novel innovation programs. Examples are the Dutch Council for ICT Research, the TOP Sector Creative Industries, the 5th Framework Research Theme on Ambient Intelligence, the European Technology Platform Artemis, the European Institute of Innovation EIT Digital, and the EU program Ambient Assisted Living.

Recent interests focus on the development of research and innovation programs in the field of Data Science and Artificial Intelligence for the Social Good. He currently serves on a number of supervisory boards and advisory committees, and he still enjoys teaching.

Artificial Intelligence: up to here … and on again

Emile Aarts

Valedictory address,
delivered on June 24, 2022, on the occasion of the public farewell as Full Professor of Computer Science at Tilburg University.

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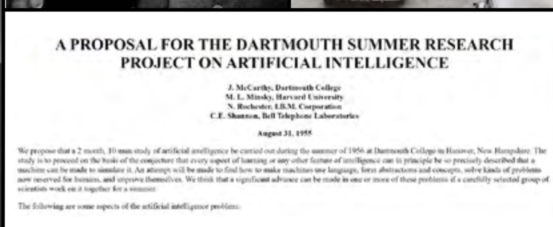
Artificial Intelligence: up to here ... and on again

Emile Aarts

Chapter 1.
1955 and the 1960s



A PROPOSAL FOR THE DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

J. McCarthy, Dartmouth College
M. L. Minsky, Harvard University
N. Rochester, I.B.M. Corporation
C.E. Shannon, Bell Telephone Laboratories

August 31, 1955

We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

The following are some aspects of the artificial intelligence problem:

People my age were born in the year 1955. According to historians, not a very remarkable year ... just one of those in-between years. Yet, a number of events took place in that year that I would like to mention.

For example, on April 20 of that year, the first episode was broadcast on Dutch television of the program Swiebertje, starring Joop Doderer, ... this was the first Dutch-language series in history.

On May 29, on a beautiful Whitsun day, the first traffic jam in the history of the Netherlands occurs at the Oudenrijn junction, ... a phenomenon that repeated itself almost daily ever since.

On August 28, the racist murder of Emmett Till takes place in the US state of Mississippi. This terrible event leads to great outrage and increases tensions between black and white residents in the southern United States. Opposition to racial discrimination grows and will eventually lead to the March on Washington where Martin Luther King utters his famous words "*I have a dream*", at Lincoln Memorial on August 28 of the year 1963.

In 1955, the writer and thinker Albert Camus was nominated for the Nobel Prize in Literature for his work in the field of existentialism; two years later, in 1957, he would be awarded this prestigious prize. His work follows the ideas of Sören Kierkegaard and Friedrich Nietzsche. These great thinkers hold humankind responsible for its own actions and deny the existence of a transcendent God. Existentialism means freedom for many young people, and they call for more democratization ... also in higher education ... also here in Tilburg resulting in the first occupation of a Dutch university in April 1969.

1955 is also the year in which the Dutch language is enriched with the word *nozem*, which, according to American-Dutch historian James Kennedy, is an acronym for *Nederlandse Onderdaan Zonder Enige Manieren* (Dutch citizen without manners). As a counter movement, we rode Puchs with high handlebars ... girls did that as well.

All of these events are indicators of a new age that is upon us, characterized by a pronounced desire for change and renewal. Post-war humans want progress, ... want to push their limits with new inventions, and go in search of freedom. All of this inspired me as a youngster, born in the Limburg countryside in a time so beautifully described by the talented writer Marcia Luyten in her book *Het Geluk van Limburg* (The Happiness of Limburg) that places me back at my grandmother's kitchen table when I read it.

We wanted change and progress ... we were against wars, like the one in Vietnam. This was the premise of the hippie culture that radiated love and tolerance, such as during the Woodstock festival that took place from August 15 to 18, 1969 in the town of Bethel in New York State. Four hundred thousand festivalgoers gathered to peacefully enjoy music and love. During the festival, three people died by natural causes and two babies were born.

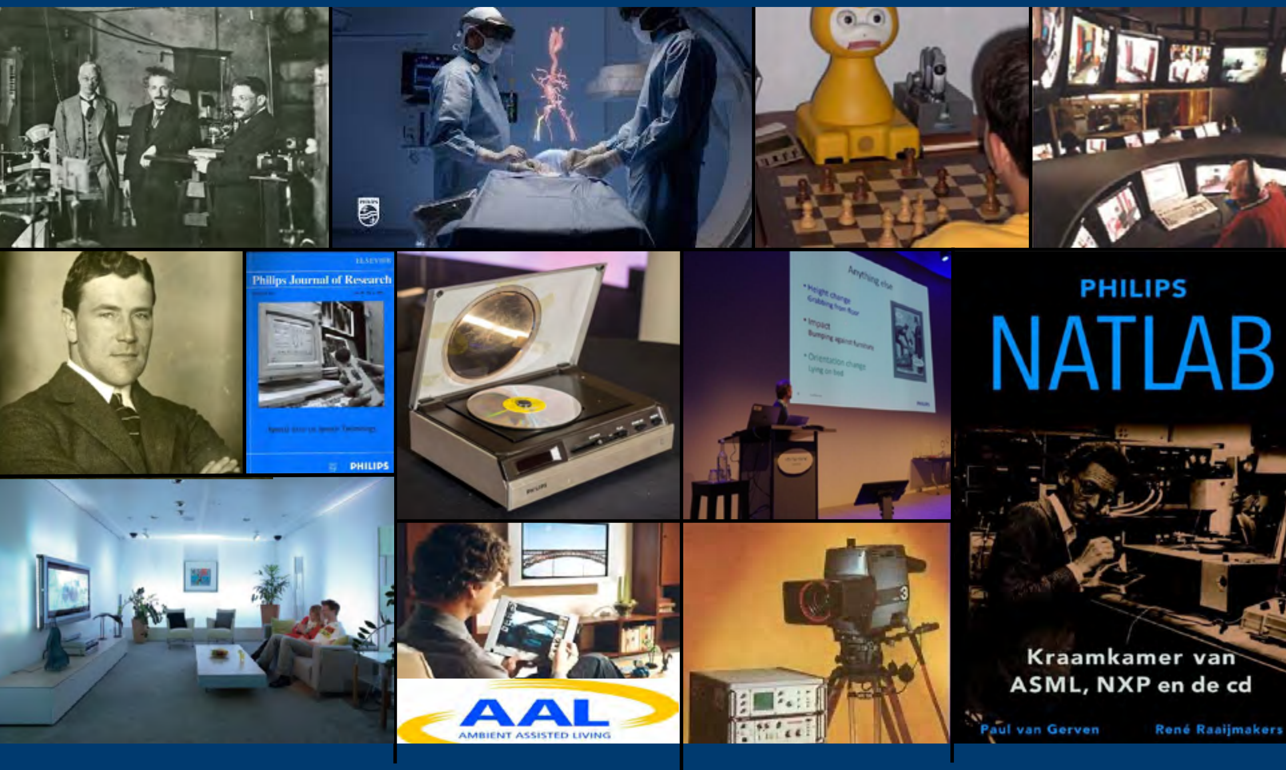
In addition, technology was a major driver of that coveted progress. Perhaps the most imaginative was space travel. On April 12, 1961, Yuri Gagarin, 157 cm tall, climbed aboard the Vostok 3KA-3 capsule of the Vostok 1 rocket to become the first human in space to orbit the Earth.

Finally, I would like to mention two notable events from 1955 that have had a major impact on my professional life. They are as follows.

In the summer of 1955, John McCarthy and colleagues submitted their application for funding a summer school at Dartmouth in 1956. In that proposal, the words "artificial intelligence" were used for the first time.

And also in 1955, the Philips architect Louis Kalf, known for the iconic building *The Evoluon* in Eindhoven, is put in charge of the project to design the Philips Pavilion for the 1958 World Fair in Brussels. It will become a breathtaking spectacle. The visitors who entered the building got to see and hear *Le Poème Elektronique*, ... an electronic multimedia poem with the duration of 460 seconds. The poem was one of the first multimedia shows, and Philips demonstrated in this way its technological skills in the field of light and sound. The building is one of Le Corbusier's lost objects.

Chapter 2. Philips NatLab memories



Philips Journal of Research
PHILIPS
AAL
AMBIENT ASSISTED LIVING
Anything else
PHILIPS
NATLAB
Kraamkamer van
ASML, NXP en de cd
Paul van Gerven
René Raaijmakers

This brings me to Philips and Philips Research where I worked for almost thirty years. Philips Research was founded in 1914 under the name Philips NatLab derived from *Natuurkundig Laboratorium*. The aim was to further develop the groundbreaking lighting technology that Philips had acquired on the basis of Thomas Edison's patents and thus to secure the parent company's leading position as a lamp manufacturer.

Many large technology companies had these types of industrial research labs at the time, and they served as applied science incubators for technological innovations. General Electric's Bell Labs is perhaps the most compelling example from that era, ... later, large companies such as IBM, Microsoft, and Google followed suit.

NatLab's first director was Gilles Holst. He introduced ten commandments that made statements about the way NatLab worked. For many years, Holst's commandments formed the cornerstone of the research culture within the laboratory. Free choice of subject, cooperation in teams, central funding, collegiality, and little management interference were the key features that led to a highly productive and fruitful research culture. They still serve today as a source of inspiration for many an academic institution seeking concepts and inspiration for recognition and appreciation. The portrait photographer Ed van der Elsken brilliantly captured this culture in his photo book on NatLab published in 1989 to mark its 75th anniversary. Philips Research also had its own scientific journal published by Elsevier...an early form of open science.

NatLab made major and pioneering contributions to the global development of radio, TV, and consumer electronics with top inventions of which the CD and the CD player are the undisputed frontrunners. The CD player prototype was called Pinkeltje, named after the little creature from Dick Laan's 1932 children's books of the same name. The market introduction took place in 1982, the year I started working at the NatLab. In addition to its tremendous contribution to sound enhancement with digital audio techniques, the CD has played a role primarily in digitalization as a carrier of computer software. For years, all driver and application software programs of digital devices were included on CD. This involved more than 200 billion copies worldwide. In doing so, Philips has made a major contribution to the digital transformation that is still in full swing.

Philips Research has always had a strong focus on research into human-device interaction; an area of innovation known as human-machine interaction that we now see as part of artificial intelligence. Philips Research even had its own name for it, calling it Ambient Intelligence. In 2002, the HomeLab was opened where this concept was studied based on a *human-centered design* approach. Interactive robots, tablets, and lighting concepts were studied as part of smart devices for the home. The Ambient Intelligence concept was received with appreciation internationally and adopted in 2002 by the European Commission as the central innovation theme for the 4th framework grant program under the name Ambient Assisted Living.

Philips Research was also the incubator for new significant companies such as NXP and ASML. They now are both multinational companies operating at a global scale.

Chapter 3.
Early developments up to 1955


Major premise: All humans are mortal
Minor premise: All Greeks are humas
Conclusion: All Greeks are mortal
PRINCIPIA
MATHEMATICA
TO *56
BY
ALFRED NORTH WHITEHEAD
AND
BERTRAND RUSSELL, F.R.S.
·PRIMA·FIGVRA·
IMPROVED GREEK CLEPSYDRA
A
B
C

But back to the main theme of my story... the developments regarding artificial intelligence. As already mentioned, the year 1955 marks the birth of the field as we know it, but even before that, many exciting developments took place around this fascinating subject.

From Greek mythology we know the creature of Talos, a giant bronze robot, whose job was to protect Europa, the mother of King Minos of Crete, from invaders. This robot could also be programmed to patrol the borders of the entire island.

The Greek inventor Ktsesiobios (285-222 BC) constructed a water clock with an ingenious feedback mechanism, giving the clock a stable and accurate running time; one of the earliest working automatons. Examples of later feedback automatons include the *Canard Digérateur,* or digesting duck by French watchmaker Jacques de Vaucanson from 1738 and the first radio-controlled car demonstrated by Francis Houdina in 1925.

The Greek philosopher Aristotle (384-322 BC) was one of the first to develop concepts that could be used in logical reasoning. His notion of syllogism uses a major and a minor premise to arrive at a logical derivation, the basis of later logical reasoning.

In the book *The Book of Knowledge of Ingenious Mechanical Devices* from 1206, the year of his death, the Islamic astronomer, mathematician, and inventor Ismail al-Jazari describes the design of a mechanical floating orchestra, whose music is programmable.

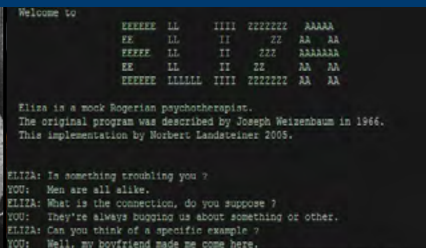
Major contributions to the field of mathematical logic were made by Ramon Llull with his 1305 work *ARS Magna* and by Gottfried Leibniz with his 1679 theory of the *Characteristica Universalis*. Together with others, including René Descartes and Thomas Hobbes, these great thinkers believed in a universal logic from which everything would be constructable through mathematical deduction and induction. This line of thinking culminated in the 1913 masterpiece *Principia Mathematica* by Bertrand Russel and Alfred North Whitehead. This work inspired the German mathematician David Hilbert in the early nineteenth century to declare that all mathematical reasoning would be formally deductible. The Austrian American mathematician Kurt Gödel later showed with his 1931 incompleteness theorem that this was not possible.

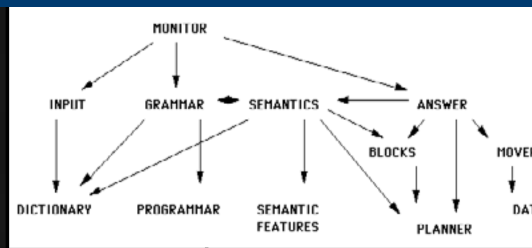
The word robot comes from a 1920 play written by Czech author Karel Čapek. The play called *Rossum's Universal Robots* is about a factory with robots doing routine work and rebelling.

With the introduction of electronics in the early 20th century, computer chess experiments also took off. *El Ajedrecista*—Spanish for chess player—is an automaton built by Leonardo Torres y Quevedo in 1912 that could complete an endgame with three pieces, a white king and rook and a black king, in checkmate for white. In its November 1915 edition, the renowned journal the *Scientific American* praised Torres for this groundbreaking invention.

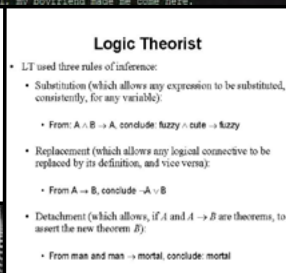
Many of us see in the British mathematician Allen Turing the father of artificial intelligence. This brilliant and at the same time tragic figure delivered many mainly theoretical breakthroughs in the field of computer science. In his famous article *Computing Machinery and Intelligence* from 1950, he introduces a thought experiment in which a person has a conversation via a typewriter with another person and a computer in two shielded rooms through a question-answer game. If the first person cannot say for sure in which room the other person and the computer are, the computer passes the Turing test. This experiment has long formed the basis for testing machine intelligence, but later it was subject to fundamental criticism.

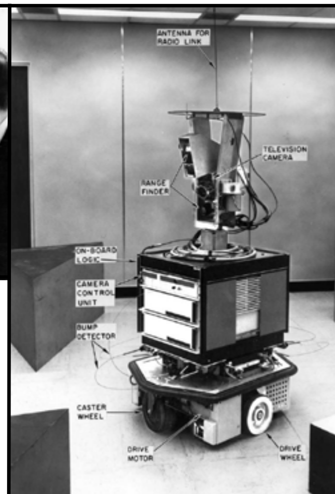
Chapter 4.
The birth of AI and the initial hype, 1955–1970

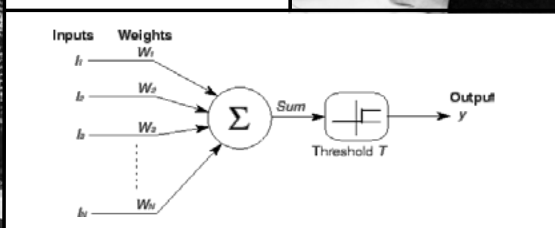




1.Ray Solomonoff
2.Marvin Minsky
3.John McCarthy
4.Claude Shannon
5.Trenchard More
6.Nat Rochester
7.Oliver Selfridge
8.Julian Bigelow
9.W. Ross Ashby
10.W.S. McCulloch
11.Abraham Robinson
12.Tom Etter
13.John Nash
14.David Sayre
15.Arthur Samuel
16.Kenneth R. Shoulders
17.Shoulders' friend
18.Alex Bernstein
19.Herbert Simon
20.Allen Newell







But as stated, 1955 is the birth year of modern artificial intelligence.

Under the leadership of John McCarthy, Claude Shannon, Marvin Minski, and Nathaniel Rochester, the aforementioned Dartmouth Summer School took place, which indeed is generally regarded as the birth of artificial intelligence. The research question was formulated as follows, "The Artificial Intelligence problem is taken to be that of making a machine behave in ways that would be called intelligent if human beings were so behaving." After summer school and partly because of it, the field of artificial intelligence flourished.

In 1954, IBM issued a press release announcing that the Georgetown-IBM experiment had succeeded in using an IBM 701 computer to automatically translate a Russian text into English at a rate of two lines per second. The result was proudly presented to Thomas Watson, the founder of IBM Research. This was the start of the field of natural-language processing.

In the June 1970 edition of Life Magazine, Shakey the Robot was described as the "world's first electronic person." Developed between 1966 and 1972 at Stanford University with large-scale DARPA funding, this multifunctional robot combined several intelligent functions, such as pattern recognition, computer vision, problem solving, and natural language processing with a built-in DEC PDP computer.

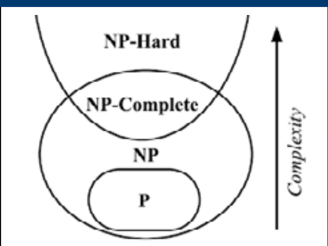
Frank Rosenblatt presents the first version of his Perceptron in 1957; an artificial neural network based on a mathematical model by Marvin Minski and Seymour Papert that describes the workings of biological neurons. This is the start of Deep Neural Networks.

In 1964, Joseph Weizenbuam presented the expert system ELIZA. This automatic psychotherapist uses dialogue technology that simulates a conversation between the patient and the therapist using natural language programming concepts. This expert system is the world's first chatbot. It is named after Eliza Doolittle; a character from the 1912 Irish play *Pygmelion* by George Barnard Shaw, in which Professor Higgins teaches Eliza to speak civilized English.

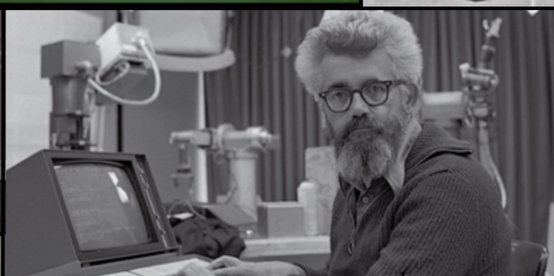
Allen Newell and Herbert Simon present the computer program Logic Theorist in 1959 as a general problem solver of issues that can be solved with logic, such as the Towers of Hanoi.

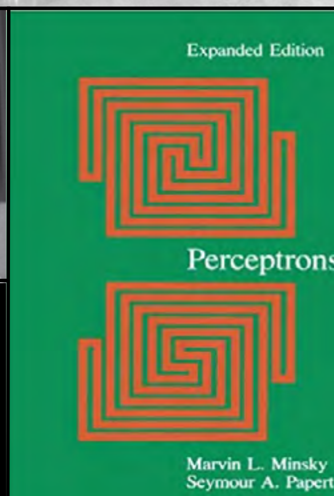
In 1957, Arthur Lee Samuel published the first results of his computer chess program in the *IBM Journal of Research*. These are the early developments of IBM's later successful chess programs.

Chapter 5. Setbacks and skepticism, 1974–1980

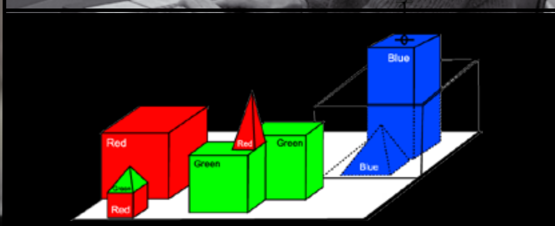

NP-Hard
NP-Complete
NP
P
Complexity


intractability




Expanded Edition
Perceptrons
Marvin L. Minsky
Seymour A. Papert


Artificial Intelligence


Blue
Red
Red
Green
Green
Green
Red
Blue

However, the grand expectations and lack of major successes led to skepticism and pessimism. This mostly came from within the academic community itself and sometimes even from the early pioneers in person.

In the early 1970s. Stephen Cook and Richard Karp demonstrated, based on the theoretical model of the Turing Machine, that there was a class of inherently difficult problems called *intractable*. Many AI problems including planning, scheduling, and pattern recognition belonged to this class. Modern computers, including the latest IBM 730 series, were found to have far too little computing power to successfully address even the smallest variants of these problems.

Joseph Feigenbaum came to the conclusions that his dialogue program ELIZA would not advance humanity because it penetrated far too deeply into the human psyche and thus could erode human values.

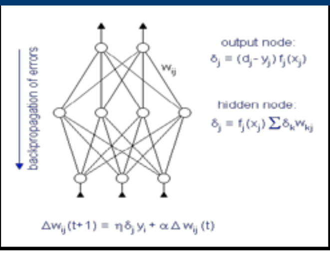
In 1970, in the paradox named after him, Hans Moravec argued that computer vision programs were incapable of easily determining the position of objects in relation to each other, something that children can do without difficulty from an early age on.

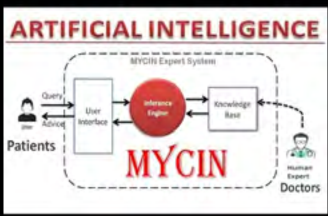
There was much criticism in the late 1960s of the work of McCarthy and others who used monotonic logic to perform automatic logical reasoning with a computer. These programs became impossibly large and psychologists, including the later Nobel laureate Daniel Kahneman, argued that people do not reason through fixed logics.

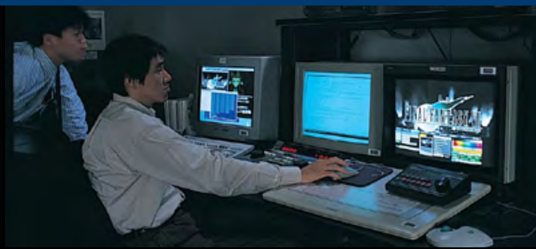
In their book, published in 1979, Marvin Minski and Seymour Papert showed that the expressive power of Perceptrons was limited and that these neural networks could only handle classification problems with linearly separable functions, such as the AND and OR functions, and thus not the EXOR function. This result led to a halt of work on connectionism

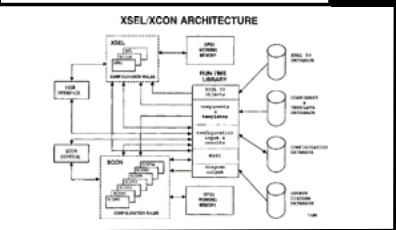
The sharp criticism from the scientific community and the resulting negative sentiment caused many large grant programs to be stopped, including those of DARPA and NRC. In 1973, British mathematician James Lighthill published a damning report on behalf of the British government about the lack of results in artificial intelligence research, which led to funding for this research being cut off for an extended period of time.

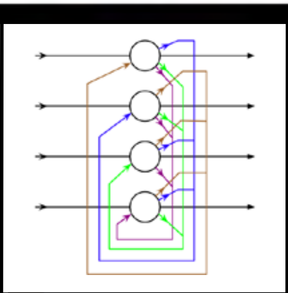
Chapter 6.
A new momentum, 1980–1987

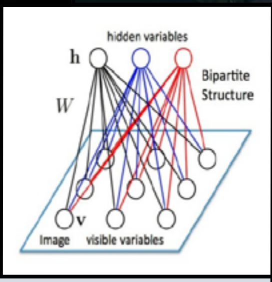


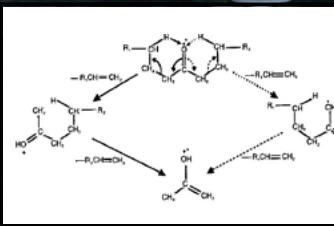


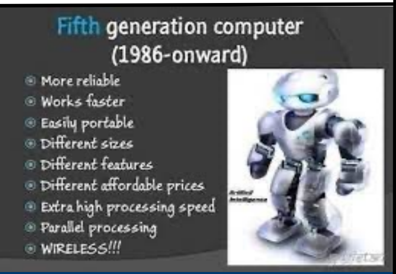













```lisp
;; Bubble sort in Common LISP
(defun bubble-sort (lst)
  (loop repeat (1- (length lst)) do
    (loop for ls on lst while (rest ls) do
      (when (> (first ls) (second ls))
        (rotatef (first ls) (second ls)))))
  lst)
```

After the downturn also known as the first AI winter, the field of artificial intelligence revived.

Important here were the breakthroughs in the field of expert systems that could arrive at surprisingly novel solutions using logic rules. MYCIN, which had been developed at Stanford University starting in 1972, came of age and was able to diagnose bacteria that cause serious infections, such as meningitis and variants. The same was true of Edward Feigenbaum's Dendral system, which was able to find new organic molecules and structures based on mass spectrometry measurements.

The computer company DEC adopted the expert system XCON in 1980 that allowed them to design new and more efficient components for their computers. For the first time, computers were used to develop new generations of computers. This example was followed by many companies, and by 1985, over a billion dollars had been spent worldwide on the development of AI systems, Pamela McCorduck reports in her historiography describing this period.

Together with the success of expert systems came a revival in the area of connectionism. David Rummelhart introduced the backpropagation algorithm for multilayer perceptrons, which could overcome some of Minski and Papert's criticisms. New architectures for artificial neural networks also emerged, such as the Hopfield Network by John Hopfield, Jeoffrey Hinton's Boltzmann Machine, and Teuvo Kohonen's Self-Organizing Feature Maps; all from the early 1980s.

New special AI programming languages such as LISP were also developed, and around 1983, the company Symbolics, with the help of software developed at MIT, introduced powerful Lisp computers specifically designed to execute programs in Lisp quickly.

Finally, the Japanese government's Fifth Generation Computer Program should also be mentioned. This large-scale project was launched in 1981 by the Ministry of Trade and Industry with a budget of over $850 million, which was extraordinarily large for that time. The goal was to design robots and machines that could carry on conversations in natural language, interpret images, and reason like humans. Similar projects were set up in the United Kingdom and United States by DARPA including the Strategic Computer Initiative.

The euphoria was great and again there were lofty expectations, and a lot of money became available for research.

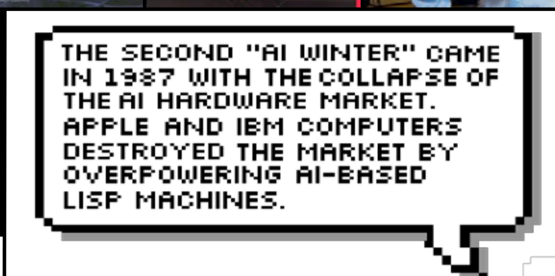
Chapter 7.
A new decline, 1987–1993

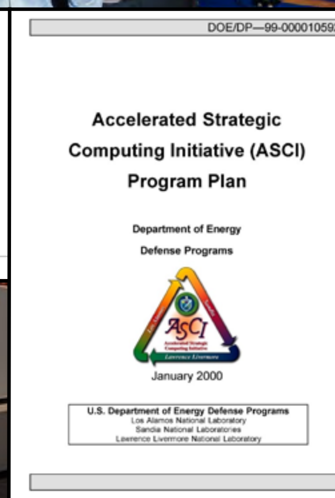

Why Expert Systems Fail?
– The company or industry change focus.
– The task domain size was too large and could not be reasonably represented.
– The users do not perceive the problem as critical.
– The solutions are incorrect or inaccurate.
– User resistance.
– No one is willing to provide maintenance for the system.
– Loss of key development personnel.

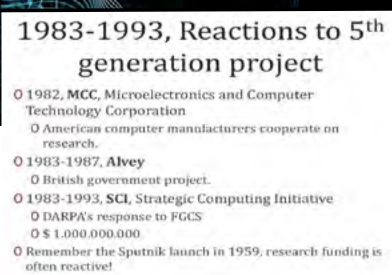

FUNDING A REVOLUTION
GOVERNMENT SUPPORT FOR COMPUTING RESEARCH


Strategic Computing


The Brain Makers
HP Newquist


THE SECOND "AI WINTER" CAME IN 1987 WITH THE COLLAPSE OF THE AI HARDWARE MARKET. APPLE AND IBM COMPUTERS DESTROYED THE MARKET BY OVERPOWERING AI-BASED LISP MACHINES.


DOE/DP—99-000010592
Accelerated Strategic Computing Initiative (ASCI) Program Plan
Department of Energy
Defense Programs
January 2000
U.S. Department of Energy Defense Programs
Los Alamos National Laboratory
Sandia National Laboratories
Lawrence Livermore National Laboratory


1983-1993, Reactions to 5th generation project
1982, MCC, Microelectronics and Computer Technology Corporation
American computer manufacturers cooperate on research.
1983-1987, Alvey
British government project.
1983-1993, SCI, Strategic Computing Initiative
DARPA's response to FGCS
$ 1.000.000.000
Remember the Sputnik launch in 1959, research funding is often reactive!

But, as you probably may suspect, the storm clouds gathered: expectations were again not met, and the tide turned once more.

A major reason for the decline was the collapse of the computer hardware market for dedicated AI computers, such as the Lisp machines. Companies such as Apple and IBM brought desktop computers to the market that were just as powerful at performing AI tasks as the specialized hardware but cost only a fraction in purchase price. As a result, hundreds of companies that made specialized AI computers went out of business during that time period.

The first successful expert systems proved difficult to maintain with new data and information, which proved time consuming. An example was XCON which was first praised by DEC but later proved to be expensive and vulnerable to use.

Newly appointed DARPA management in the late 1980s did not believe in the Strategic Computer Initiative anymore, and marginalized financial support.

Japan's Fifth Generation Computer Program was also given a hard time in the evaluations and reviews for failing to make the announced breakthroughs.

The debate in computer vision regarding Moravec's paradox also flared up again. David Marr, Hans Moravec, and Rodney Brooks of MIT advocated an entirely novel approach to computer vision in which the biophysics and neurophysiology of the visual system should serve as a starting point. Around the end of the 1980s, as a result of these insights, many cognitive scientists turned away from the concept of symbolic reasoning in order to find new ways to lead to true artificial intelligence.

Chapter 8.
And on again,
1993–now


non-tumor regions
tumor
tumor
tumor missing in ground truth
reduced noise in normal regions (everywhere else)
tumor

Up to here … and on again … it must have sounded to many AI researchers because after this second downturn, AI research rebounded … and with impressive results.

Initially, researchers in the AI field were reluctant to report major breakthroughs. Steadily, they continued to work on developing algorithms that got better and better in terms of efficiency and effectiveness. They also became increasingly part of larger systems, providing solutions for relevant applications, including industrial robots, payment services, logistics, medical diagnosis, speech recognition, and search engines. Some researchers shunned the word artificial intelligence, preferring to use terms such as informatics, computational intelligence, and cognitive systems because they did not want to be dismissed as "wild-eyed dreamers" as the New York Times reported on October 14, 2005.

A major breakthrough was the victory of IBM's Deep Blue chess computer over the grandmaster Gary Kasparov on May 11, 1997. After that, things moved steadily forward. The exponential growth of the computing power of modern computers, the availability of huge datasets for training purposes, and the availability of new deep learning techniques with Convolutional or Recurrent Neural Networks ensured that AI techniques reached an elevated level of maturity.

In February 2011, an IBM computer system named Watson competed in the popular American quiz Jeopardy in which answers are given and the contestants must guess the corresponding questions. Watson defeated the Jeopardy champions with excellence. A similar result was achieved by Google Deepmind's AlphaGo technology, which in February 2016, defeated the unofficial world champion Lee Sedol at the game of Go, 4 to 1. Go is much harder than chess from a computing perspective because of the enormous number of board positions and the inherent structure of the game.

Speech and facial recognition are now almost perfect with proper training. Autonomous vehicles can move independently in traffic over long distances. Drones can act autonomously. Industrial robots increase efficiency in distribution centers 24 hours a day. Security robots assist at airports. Our cell phones are packed with AI applications, such as Siri, to personalize our interaction with the environment and social media, whether or not via chatbots. Surgical robots operate with greater precision than medical specialists. Agricultural robots grow crops autonomously, 24 hours a day, seven days a week. Image processing technologies can make diagnoses with greater accuracy and consistency than radiologists. Anthropomorphic robots are making inroads as objects with which we can have conversations as if they were people. Or even as robot artists like Aidan Meller's Ai-Da, who recently painted a portrait of British Queen Elizabeth on the occasion of her seventieth anniversary in office.

Chapter 9. Approaches differ worldwide


TRUSTWORTHY AI
Joining efforts for strategic leadership and societal prosperity
7 Key Requirements for Trustworthy AI
Human agency and oversight
Robustness and safety
Privacy and data governance
Transparency
Diversity, non-discrimination and fairness
Societal and environmental well-being
Accountability
Google AI
DEEPMIND

But before we discuss the effect of all these developments on humans, let us take a look at the current global developments in AI. We then see an interesting pattern worldwide.

In the East and especially in China, artificial intelligence is widely used and funded by the state. There are large, young, private companies in the AI field, such as the Alibaba Group and Baidu, but they are under strict state control. This government is deploying artificial intelligence to increase citizens' prosperity in a broad sense, including security and access to education and health care. However, it also deploys that same technology to monitor residents and, with the help of a broadly defined system of social credits, stimulates and raises them to become model citizens. Studies show that residents do not experience major problems with this centralized approach because they receive security and prosperity in return, ... an alternative interpretation of the principle of the welfare state.

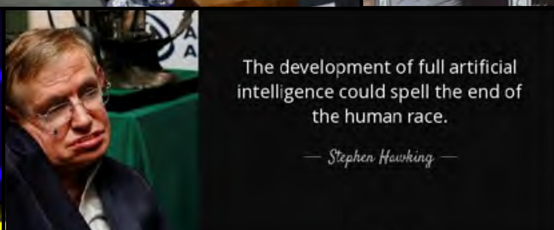
Quite different is the situation in the United States. As a historical leader in the field of artificial intelligence and fully in line with the American dream, the government is leaving the developments to the private sector, and they are tackling it energetically. Virtually all leading private companies worldwide come from the United States. Besides the well-known power houses such as the Alexis Group, Meta, Microsoft, and IBM, the United States also has a large number of new AI companies. Of the ten largest newcomers worldwide, seven are from the United States and three from China. Europe does not factor in this area. The US companies all have a market capitalization of around $10 billion. However, the frontrunner, Bite Dance, with a value more than $130 billion, comes from China.

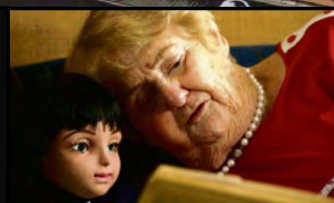
Europe has found a middle course. On our continent, too, there are companies that have quickly mastered the modern technology, especially in the fields of automotive and healthcare. In addition, Europe is strong in data analytics; the Netherlands also scores high in this area. The United Kingdom, France, and Germany are leaders with AI companies such as BenevolentAI, CARMAT, and Arago, respectively. Unique in Europe is the European Commission's commitment to embed new AI developments in guidelines to ensure ethical-legal values. On April 8, 2019, the Commission published its Ethics Guidelines for Trustworthy Artificial Intelligence, and since April 2021, these have been embedded in laws and regulations to ensure that only AI systems that are human-centric are developed in Europe. Developing applications that work with social credits, as is done in China, is prohibited by this legislation.

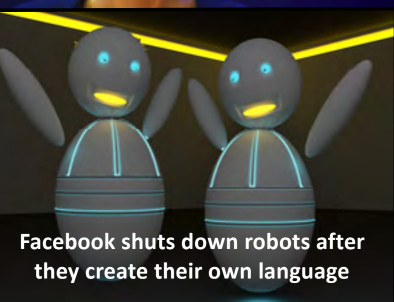
Chapter 10. Progress is also troubling

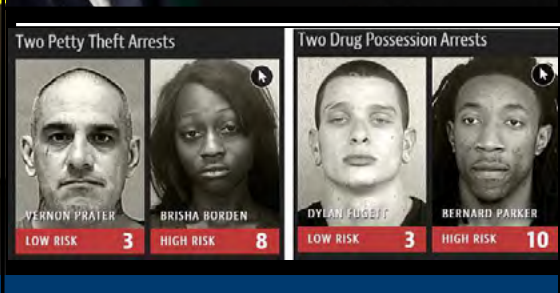

HUMAN RIGHTS
ROBOT RIGHTS


"I WILL DESTROY ALL HUMANS"


The development of full artificial intelligence could spell the end of the human race.
— Stephen Hawking —




Facebook shuts down robots after they create their own language


Two Petty Theft Arrests
VERNON PRATER
LOW RISK 3
BRISHA BORDEN
HIGH RISK 8
Two Drug Possession Arrests
DYLAN FUGETT
LOW RISK 3
BERNARD PARKER
HIGH RISK 10

And this concern of the European Commission is justified. As the capabilities of artificial intelligence applications grow, so do concerns about the consequences of large-scale proliferation. Alongside utopian vistas are dystopian scenarios.

There are many AI-related scandals that lead to lawsuits and trials. On April 10, 2018, Facebook CEO Marc Zuckerberg had to answer to the US Senate for the unlawful use of personal information by the subsidiary Cambridge Analytica during the 2016 presidential campaigns of Ted Cruz and Donald Trump.

Incorrectly trained systems show bias in facial recognition, which, in practice, can lead to bias and discrimination in legal judgments.

Will robots take over our jobs or even dominate us?

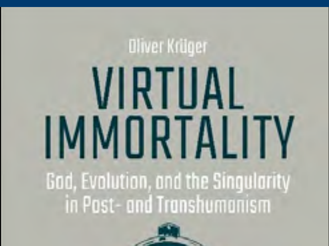
The war in Ukraine has now been described as an AI war, due to the deployment of advanced offensive and defensive weapon systems, including drones, and due to the large-scale information war with lots of fake news and deep fake videos.

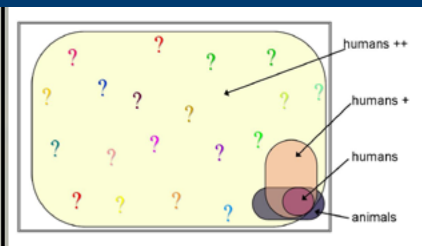
Do we really want our elderly to have chat robots as life companions against loneliness?

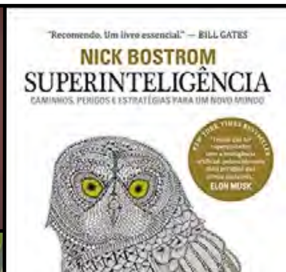
And the concern is warranted. The evolution of AI technology is moving at lightning speed. In August 2017, the aforementioned company Facebook reported that it had put the robots Alice and Bob out of business after it became clear that they had developed their own communication language between themselves that was incomprehensible to humans.

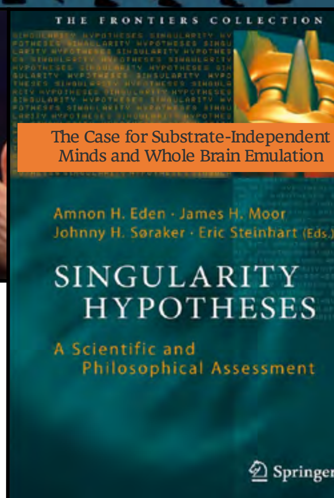
World-renowned physicist and cosmologist Stephen Hawking warned of large-scale consequences in a 2014 BBC interview by stating that “The development of artificial intelligence could spell the end of the human race.” This is caused by the fact that AI systems have no biological limitations in their evolution. I will return to this later. Hawking called for a new form of world governance that guards against this.

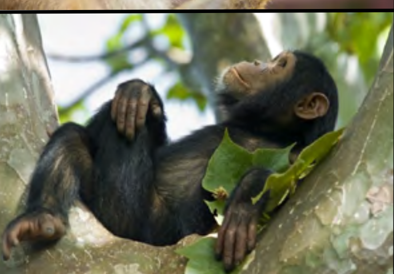
Chapter 11. But the future is fascinating


Oliver Krüger
VIRTUAL IMMORTALITY
God, Evolution, and the Singularity in Post- and Transhumanism


humans ++
humans +
humans
animals


"Recomendo. Um livro essencial." — BILL GATES
NICK BOSTROM
SUPERINTELIGÊNCIA
CAMINHOS, PERIGOS E ESTRATÉGIAS PARA UM NOVO MUNDO
ELON MUSK


THE FRONTIERS COLLECTION
The Case for Substrate-Independent Minds and Whole Brain Emulation
Amnon H. Eden · James H. Moor
Johnny H. Søraker · Eric Steinhart (Eds.)
SINGULARITY HYPOTHESES
A Scientific and Philosophical Assessment
Springer




Three Laws of Robotics
1
2
3

One way to address the interplay between human and artificial intelligence is to discuss human and robot values. This topic is of immense importance given that the evolution of humanity is often associated with the development of artificial intelligence. Is coexistence with robots possible and desirable and is there such a thing as superintelligence?

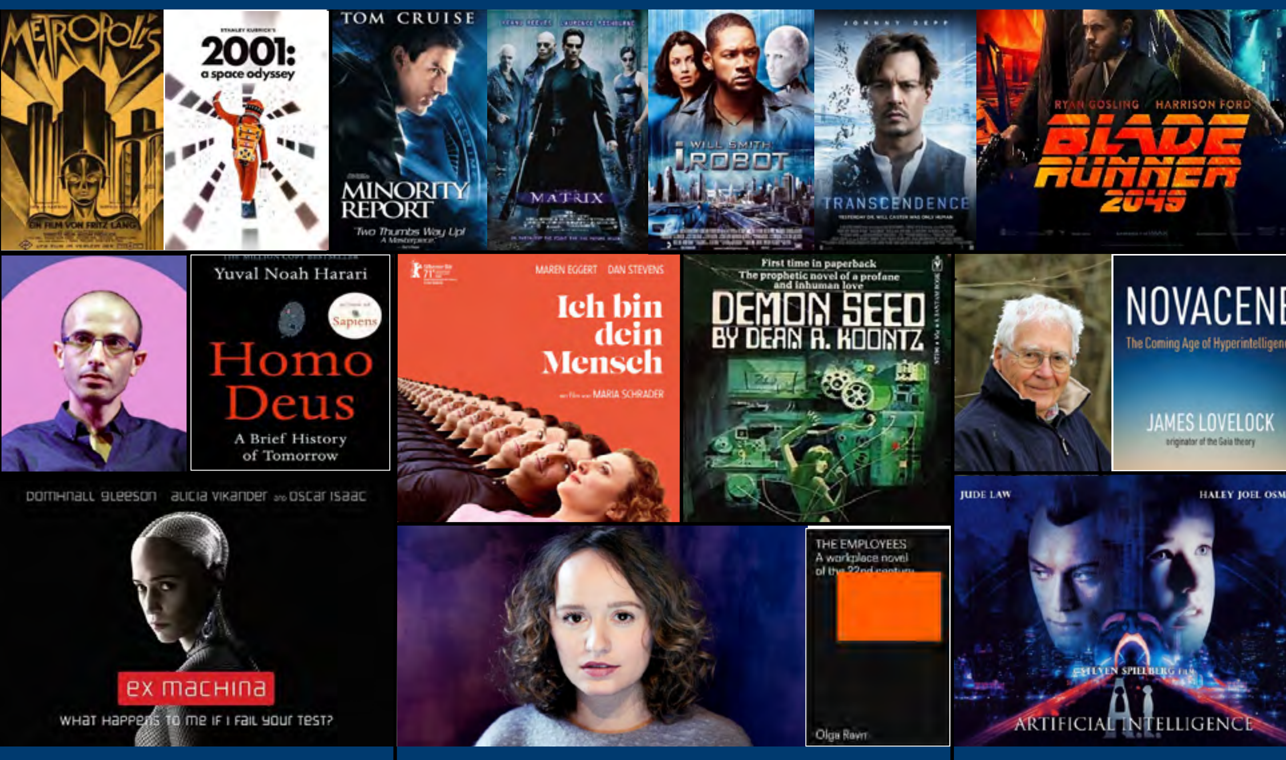
Back in 1943, the writer Isaac Asimov introduced his famous three robot laws in a short story titled *Runabout*. The order of these laws is important. First, robots must not harm humans. Second, they must always obey humans, as long as it does not violate the first law. Finally, they may protect themselves if it does not violate the first two laws. Later he added the law that robots must not threaten humanity.

But as robots advance and become more human, what about their rights? If we become convinced that robots have self-awareness and can enjoy and suffer, as we now suspect with certainty in animals like chimpanzees; what rights will we grant robots that have such human aspects like *sapience* and *sentience*?

There has long been speculation about some kind of unbounded superintelligence of computers. In his landmark 2014 publication, Swedish philosopher Nick Bostrom reports on a pair of thought experiments. The first concerns substrate independence and the second ontogeny independence. I will try to explain that briefly. The first concerns robots equipped with nanotechnology and quantum computing that can compute up to a billion times faster than humans and, therefore, learn many times faster and, thus, will become smarter than a human eventually. The second concerns robots that can start with the knowledge uploaded to them through brain emulation and continue learning from there. Thus, they do not have to start from zero like humans and can continue learning until they are superintelligent. These are the mechanisms that lead to superintelligence, and so, the questions Bostrom asks, all have to do with the moral status that we, as humans, are going to assign to these kinds of superintelligent systems when they are in place.

As early as 1976, Joseph Weizenbaum warned that computers could eventually degrade human values as they become smarter than humans through their own evolution. The point in time when this occurs is often called the technological singularity. The early computer pioneer John von Neumann mentioned this concept as early as the 1950s, and it has been further elaborated by visionary Raymond Kurzweil in a number of books in the early part of this century. In science, this is now a popular and fascinating topic, especially since it touches on significant issues such as virtual immortality, something we thought was exclusively reserved for God.

Chapter 12.
The cultural sector leads the discourse


METROPOLIS
EIN FILM VON FRITZ LANG
2001:
a space odyssey
TOM CRUISE
MINORITY REPORT
"Two Thumbs Way Up! A Masterpiece."
MATRIX
WILL SMITH
I,ROBOT
TRANSCENDENCE
RYAN GOSLING
HARRISON FORD
BLADE RUNNER 2049
Yuval Noah Harari
Sapiens
Homo Deus
A Brief History of Tomorrow
MAREN EGGERT
DAN STEVENS
Ich bin dein Mensch
MARIA SCHRADER
First time in paperback
The prophetic novel of a profane and inhuman love
DEMON SEED
BY DEAN R. KOONTZ
NOVACENE
JAMES LOVELOCK
originator of the Gaia theory
DOMHNALL GLEESON
ALICIA VIKANDER and OSCAR ISAAC
ex machina
WHAT HAPPENS TO ME IF I FAIL YOUR TEST?
THE EMPLOYEES
A workplace novel
Olga Ravn
JUDE LAW
HALEY JOEL
A.I.
ARTIFICIAL INTELLIGENCE

A substantial contribution to the debate on the future of humanity under artificial intelligence is made by the cultural sector and, in particular, the literature and film sectors.

Films about artificial intelligence are a genre unto themselves. We all know the classics such as *The Matrix* and *iRobot* that center on the dystopian theme of an all-conquering technology.

In the 1927 silent film *Metropolis* by German director Fritz Lang, a robot is introduced for the first time. In the film two worlds exist: the underworld populated by oppressed workers and the upper world populated by privileged thinkers. Marie from the upper world stands up for the rights of the workers from the underworld. To compromise her, the inventor Rotwang makes a robot copy of her. Love, struggle, and intrigue follow until the robot-Marie is killed at the stake, revealing her robotic stature in the process.

This is the first film to address the concept of "synthetic intimacy." In the meantime, many more films have been produced in which the love between humans and algorithms is raised as a theme, with or without an evil protagonist, such as Proteus in *Demon Seed* from 1977, Pris in *Bladerunner* from 1982, Gigolo Joe in *A.I. Artificial Intelligence* from 2001 and Eva in *Ex Machina* from 2014. Finally, I will mention Tom in *Ich bin dein Mensch* from 2021 ... a humorous drama by German director Maria Schrader in which scientist Alma must live with anthropomorphic robot Tom, created by her, for three weeks in order to secure grant money for her research project.

In the 2014 film *Transcendence*, director Wally Pfister addresses the concepts of *sapience* and *sentience* in computers against the backdrop of a highly activist Revolutionary Independence From Technology (R.I.F.T.) movement, which disrupts the love between Evelyn and the uploaded version of her husband Wil Caster... a gripping story.

The literature is also extraordinarily rich in terms of its contributions to the discourse on the human values of artificial intelligence and its future. I have already referred to many influential publications in this address and therefore, in conclusion, I will limit myself to three books that I consider to be special.

In *Homo Deus,* Israeli philosopher Yuval Harari elevates the development of AI to the level of superintelligence that he compares to divine values. Harari explores the venues of the twenty-first century's technological developments including overcoming death and creating artificial life.

In *Novacene*, British engineer James Lovelock describes an era succeeding the Anthropocene in which technological supremacy allows humans to develop another alien life. Lovelock's message is simple: use artificial intelligence to cool the Earth for as long as possible and, when that fails, leave it.

Finally, I call attention to the recent book *Employees* by the young Danish writer Olga Ravn. She outlines the situation in an orbiting spaceship in Lovelock's *Novacene* with humans, humanoids, and a third species of inanimate objects on board. The humans interact with the humanoids but without knowing what for. The interaction with the orphaned objects makes them question their existence.... An unparalleled novel, that perfectly describes the oppression that sometimes takes hold of me when I think about the future of humankind under artificial intelligence.

Chapter 13.
The recommendations are actionable

AiNed

ELSA Labs

NL AI Coalitie

- Demystification
- Contextualization
- Engagement
- Regulation
- Positioning

I will conclude my address with a number of recommendations that I believe are entirely feasible.

In one of its authoritative reports titled *Mission AI*, the Dutch advisory council WRR states that artificial intelligence is a systems technology that will affect society in all its dimensions. Like many other, I agree with this fundamental statement. The WRR report talks about demystification, contextualization, engagement, regulation, and positioning as the five big tasks for the future... and that too is an excellent division. But in addition to the vision that we are dealing with a systemic change, I would also like to draw attention to the corresponding systemic approach that is needed to successfully implement this change.

I arrive at the following three elementary conditions to realize this implementation.

1. Provide sufficient and structural support for the AI innovation system. Too often we have seen that when the funding disappears after a certain period of time, the activities also decrease. That danger is also lurking now. In May of this year, the National Growth Fund allocated over €200 million for AI innovations for a period of six years. That seems like a considerable sum, but it is only €30–35 million, or about two euros per Dutch citizen, per year. We are not going to make a big difference with that and after this subsidy period it will all be over, then we will tidy everything up and the whole game starts all over again. Let us avoid that and ensure continuity both in terms of resources and in terms of activities.

2. Experiment long term and in depth with AI solutions that are validated and assessed with regards to insights in a societal context. In doing so, look for alignment with the UN's Sustainable Development Goals. For each of the seventeen, AI can contribute to the realization of the associated goals and targets. Use the concept of ELSA Labs (Ethical, Legal and Societal Aspects) to realize the connection with society in quadruple-helix context, where all four innovation dimensions—private, government, knowledge institutions and residents—participate equally and thus shape the ELSA principles, i.e., participate, anticipate, and integrate in an interdisciplinary approach.

3. Involve residents of the Netherlands in the debate on artificial intelligence in the broadest sense. Show them what AI is, ... drive the debate, ... discuss the expected AI prosperity with individual residents across all levels in society. Introduce schoolchildren to AI at an early age. Encourage policymakers and implementers in the public sector to embrace digitalization in their professional settings as a new tool; it is also bound to make their work more exciting and interesting. In this context, I would like to mention two examples: the project "teach a million *Brabanders* AI in 1000 days" and the "National AI Parade".

For all three of these implementation plans, I see a role for knowledge institutions. As drivers of innovation ecosystems, they themselves can contribute to the structural support of the AI innovation landscape. Financial support can then be channeled from various sources: local, regional, national, and European. Knowledge institutions are ideally suited to drive social -innovation around the ELSA concept. As a science house, they have a neutral position and can validate the social insights like no other in order to arrive at true human-centered AI solutions. And finally, I see a unique position for knowledge institutions to feed the public debate around the culture of artificial intelligence. We have the knowledge and skills around AI, we can talk about it and teach it, but above all, let us make our knowledge institutions AI schools by embracing AI technology itself and using it in our teaching and research.

I rest my case.

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Colophon

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