UNTITLED, COMPUTER; IS AI CREATIVE?

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2016-09-25

8803 words of Helvetica Neue type

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Introduction

Can a computer think in the way that humans do? Can Artificial Intelligence be creative? And can it do so autonomously, without the interference of a human being?

As Artificial Intelligence slowly but surely becomes embedded within the software and hardware used by humans in their everyday lives, some investigations as to the possibilities and limits of AI seem relevant. For in the last decade we see a surge of new Artificial Intelligent related applications being developed. They are as diverse as intriguing, from self-driving cars to digital personal assistants, all seem potentially to have a profound impact, as to what kind of activities will, in the next decade or so, be executed by humans and what by artificial agents.

As an artist, one might think that, at least making art, as an exclusively human endeavour, would be safe from artificial replication. Surely a computer could not simulate creativity? That singular trait that most people believe makes us human could never be reproduced artificially, right? Or could it?

When looking at these questions closely, it becomes clear that there has to be some consideration as to the definition to certain terms. For what is creativity in the first place? And how do we define autonomy?

In this dissertation, I will explicate the questions mentioned above by first providing the reader with a general understanding of how a computer functions, and to explain its development and its purpose. For let us assume that the computer has the potential to be creative autonomously, how would we verify such a fact if we do not understand exactly what it does and how it does so? How are we to discern fact from fiction in regards to statements that within the next decades, Artificial Intelligence will be equal to ours?

Secondly, this dissertation will focus mainly on only two aspects of Artificial Intelligence, since the field is vast and encompasses many subfields. These two aspects are, creativity and autonomy. By studying specific cases in a chronological order, not only will I outline the development of Artificial Intelligence from its early years to the present time, also I will point out to what degree the computer is creative in each separate case, and to what extent the computer operated in a autonomous way.

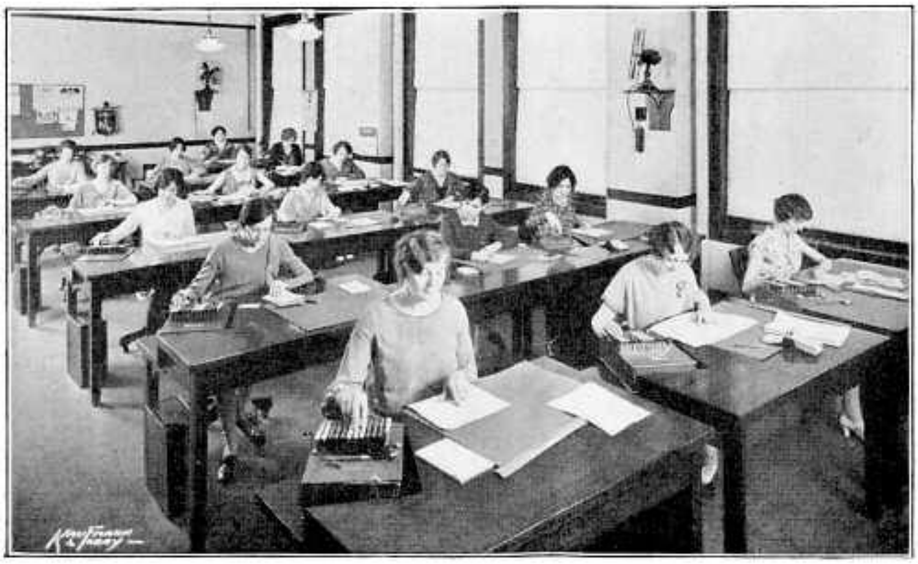

Fig. 1 Central computing bureau, Peoples Gas Light & Coke Co., Chicago, 1929

Chapter I

Early Computers

Because the scope of this dissertation does not allow for a full overview of every step in the development of computers, this summarization written below is a culmination of moments in its early history, that are relevant to our subject matter. In this brief analysis, I aspire to demonstrate a historically intrinsic relationship between computers and human beings, to investigate how this relationship evolved, and to explore when and how the idea was brought into existence, that in the near future, a machine could possibly replace or even surpass the human mind and its capability for creative thoughts.

1.1 *Brainwork*

The first computer was human. The word 'computer' is in fact derived from the word *computare,* meaning to calculate in Latin, and was originally used for a person who does exactly so. An interesting detail, for in more recent times, our associations with the word computer are very different. It, in a way, contextualizes our innate and complex liaison with this machine. Nevertheless computers referred to people from the late eighteenth century until the end of the Second World War (1939-1945). Men and woman, old and young, well educated and common, it was humans who did the calculations.[1]

Many at the time understood, that it took a group effort of human computers to solve complex mathematical problems. The greater the complexity of the problem however, in most cases, demanded an exceeding number of 'computers',[2] and this was not very cost effective to say the least.

Thus was the separate conclusion of respectably: French civil engineer Baron Gaspard de Prony (1755–1839) and British computer Peter Barrow (1776–1862*)*.[3] Both men where undertaking the arduous task of comprising a series of volumes on trigonometry and logarithmic tables. It took de Prony, eighty computers and at least six years to produce the volumes, and as Barlow noted:

> The time employed in the computation, the expense of publication, and the limited number of purchases, which from the nature of the subject is to be apprehended, preclude every idea of adequate remuneration.'[4]

1.2 *The Difference Engine*

Expenses were not the only drawback of using human intellect for computing. Most of the work done by the legion of computers where rife with errors. Some tables of logarithms had over one thousand miscalculations. It was in fact this aspect of human computers, that frustrated Charles Babbage (1792-1871) enough to come up with a solution,[5] something that would replace human fallibility for uncompromising precision. To quote Babbage himself: '[…] it is indeed of great importance that calculations made by machinery should not merely be exact, but that they should be done in a much shorter time than those performed by the human mind.' [6]

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[1] http://www.philsoc.org/2001Spring/2132transcript.html [accessed 15 August 2016]

[2]http://www.philsoc.org/2001Spring/2132transcript.html [accessed 15 August 2016]

[3]http://www.philsoc.org/2001Spring/2132transcript.html [accessed 15 August 2016]

[4]http://www.philsoc.org/2001Spring/2132transcript.html [accessed 15 August 2016]

[5] Eric G. Swedin, David L. Ferro, *Computers: The Life Story of a Technology* (Baltimore: Johns Hopkins University Press, 2005), p.14.

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[6] Charles Babbage, *The Life of a Philosopher* (London: Longman, Roberts & Greene 1864), p.59.

Babbage imagined a machine that could mechanically solve complex mathematical problems. This so-called *Difference Engine* could add, subtract, multiply and divide (polynomial functions), but the most noticeable aspect of this particular machine, was that it did all of this without the human mind assisting the machine in its execution.[7] Although not the first mechanical calculator to be engineered, it was vastly more advanced than any other. [8]

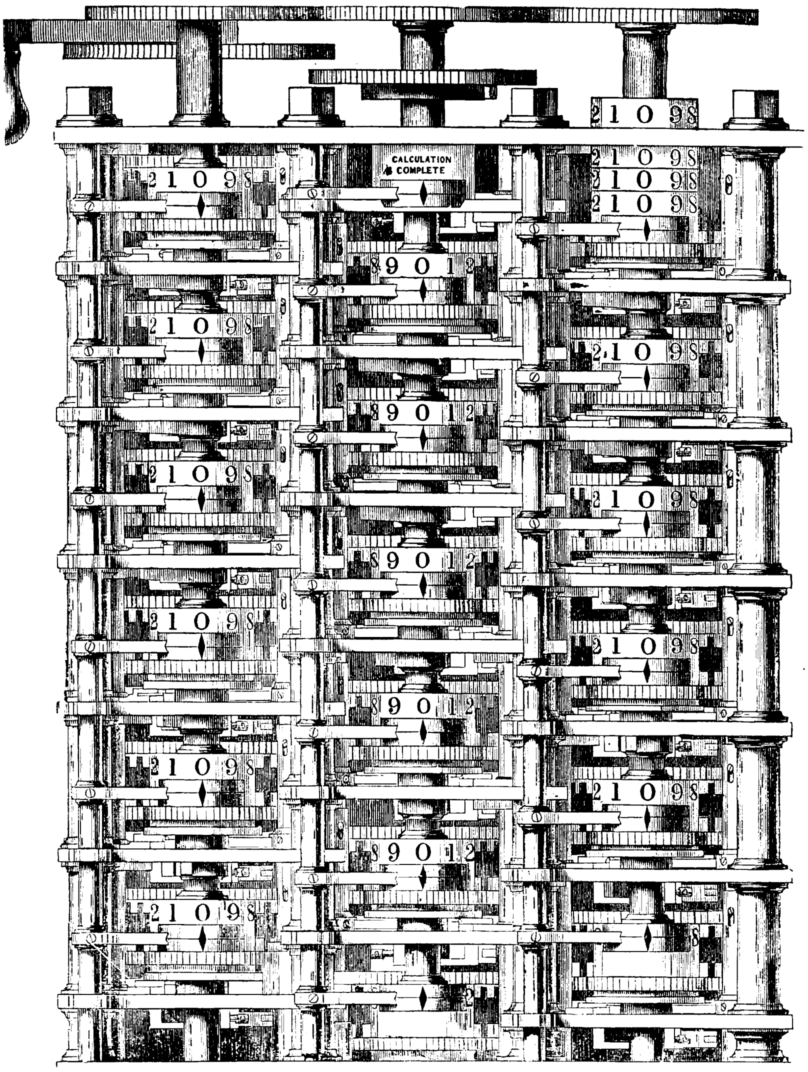

Fig. 2 Woodblock print of a portion of Charles Babbage's *Difference Engine,* 1853

[7] Charles Babbage, *The Life of a Philosopher* (London: Longman, Roberts & Greene 1864), p.41.

[8] Anthony Hyman, *Charles Babbage, Pioneer of the Computer* (Princeton: Princeton University Press, 1982), p.48.

1.3 *The punch card*

Furthermore, it was programmable. This meant that the person using the machine could provide it with a ‘programme’, a sequence of operations punched out on a card. The machine would eventually execute these operations; a sequence of numbers would be its output. In the case of Babbage’s Difference Engine, the numbers would be ‘printed’ on a copper plate.[9]

The punch card system, like the one used by Babbage, was not only fundamental for Babbage’s next idea, the *Analytical Engine*, which is considered to be the first realizable design for a general-purpose computer, the punch card system itself, remained fundamental in the programming of early computers, and was used well into the 1950s by companies like IBM.[10] The system is in fact an effective, although very basic way of communicating with a computer. The human provides the computer with a task by means of a punch card, which it then subsequently can perform.

As will be explained further in this dissertation: the way we communicate with the computer defines our relationship with it. A punch card system is an example of a very straightforward relationship. However, when our mode of communication becomes more complex, like for instance the evolution from a punch card system towards a programming language, our relationship with the computer becomes proportionally more complex. Eventually, as coded language becomes imbued with algorithms so sophisticated that it almost defies our comprehension, it could lead to a disconnected, undefined relationship with the computer as a result.[11]

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[9] Charles Babbage, *The Life of a Philosopher* (London: Longman, Roberts & Greene 1864), p.46.

[10] Paul, E Ceruzzi, *A History of Modern Computing* (Cambridge MA: The MIT Press,1998), p.18.

[11] Wendy Hui Kyong Chun, *Programmed Visions, Software and Memory* (Cambridge MA: The MIT Press, 2011), p.18.

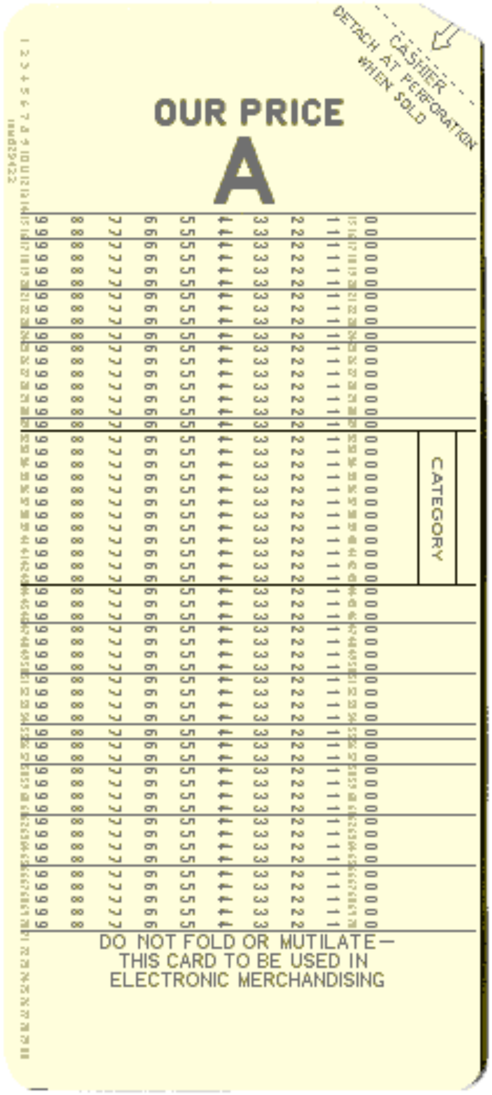

Fig. 3 IBM punch card from the 1950s

1.4 *Plankalk*ül

During the *Second World War*, participating nations knew all too well, that it would not just be superiority in terms of military numbers that could tip the balance in their favour, but technological superiority as well. To gain the edge in advanced trigonometry or code breaking technology was a strong argument for governments to invest in computer related developments. Axis powers and Allies, recruited engineers, mathematicians and scientist for their cause.

One of the most prolific computer scientists at the time was German engineer Konrad Zuse (1910-1995). His efforts during the war, eventually led to the development of the Z3, the world's first fully automatic digital (electromechanical) computer. However, even more so, was his contribution to computer science after the war, as to the development of programming languages.

Plankalkül was the first high-level computer programming language to be designed.[12] Although it was never implemented, and 'rediscovered' so to say many decades later, Plankalkül (a contraction of the German words *Plan* meaning program and *Kalkül* meaning calculation. was very much ahead of its time. It was in fact the forerunner of many of the programming languages that exist today.[13]

To understand the relevance of the Plankalkül programming language for our investigation, that is considering the possibility of creativity in computers, one must fathom the consequences of a high-level programming language for inter human-computer relationships. Keep in mind that, for a computer to create on its own accord, purposefully and not by accident, it has to be programmed in the first place. To program a computer in such a way, demands a very elegant language that can relay abstract concepts. Before Plankalkül, the communication between human and computers was extremely basic. Plankalkül laid the foundation for symbolic processing, as we shall see later on in this dissertation. As for Zuse himself, he considered that Plankalkül could not only be used for mathematical problems, but also for solving artificial intelligence processing problems of many kinds.[14]

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[12] Raul Rojas, Ulf Hashagen, *The First Computers: History and Architectures* (London: The MIT Press, 2000), p.277.

[13] Raul Rojas, Ulf Hashagen, *The First Computers: History and Architectures* (London: The MIT Press, 2000), p.277.

[14] Pamela Mccorduck, *History of Artificial Intelligence* (San Francisco: Taylor & Francis,1977), p. 952.

1.5 *Turing*

For all that it was, the Second World War proved very significant for the development of computers. In England, at the British Cryptanalytic Department in Bletchly Park, hut number eight, a young mathematician was creating a so-called 'Bombe' to decipher the unbreakable Enigma code. His name was Alan Turing (1912-1954) who at the time was just twenty-six years of age. He had already published important articles on computing, like the Church-Turing thesis,[15] and in his short life would change the way we think about computers and the way computers 'think'.

In his article *On Computable Numbers, With an Application to the Entscheidungsproblem* (1936), he made his most notable contribution to the development of the modern computer. In this article, he introduced the concept of a Turing machine.[16] This Turing machine however, is neither a computer nor a machine per se. The Turing machine is a computer on paper. A computer that is more similar to a mathematical theorem, but nevertheless laid the groundwork for the concept of the computer as we know it today.

For the first time in history, the idea of a modifiable storage was introduced. Turing envisioned this as a type of paper tape on which symbols could be printed or erased by the Turing machine.[17] Theoretically, the computer could now have a memory.

1.6 *Aftermath*

The advent of computer storage, signals a remarkable change in our attitude towards the computer. Also the speed, in which the computer was able to calculate mathematical problems, was astronomical in comparison with the computers in the time of Babbage. It now has become more than just a calculating machine. The people involved in the development of the computers, now began to realize the potential of this exceptional machine. This becomes

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[15]Alan Turing, 'On Computable Numbers, With an Application to the Entscheidungsproblem', *Proceedings of the London Mathematical Society*, Series 2 (1936), p.3.

[16]Andrew Hodges, *Alan Turing: The Enigma* (London: Randomhouse, 1983), p.316.

[17] Alan Turing, 'On Computable Numbers, With an Application to the Entscheidungsproblem', *Proceedings of the London Mathematical Society*, 2 (1936), p.233

apparent from the tone in which they begin to write about the computer and related subjects. One of those texts is from Turing himself. This now famous article *Computing Machinery and Intelligence* (1950) introduces the idea of a non-human intelligence. It is from this article onward, that the history of artificial intelligence begins.[18][19]

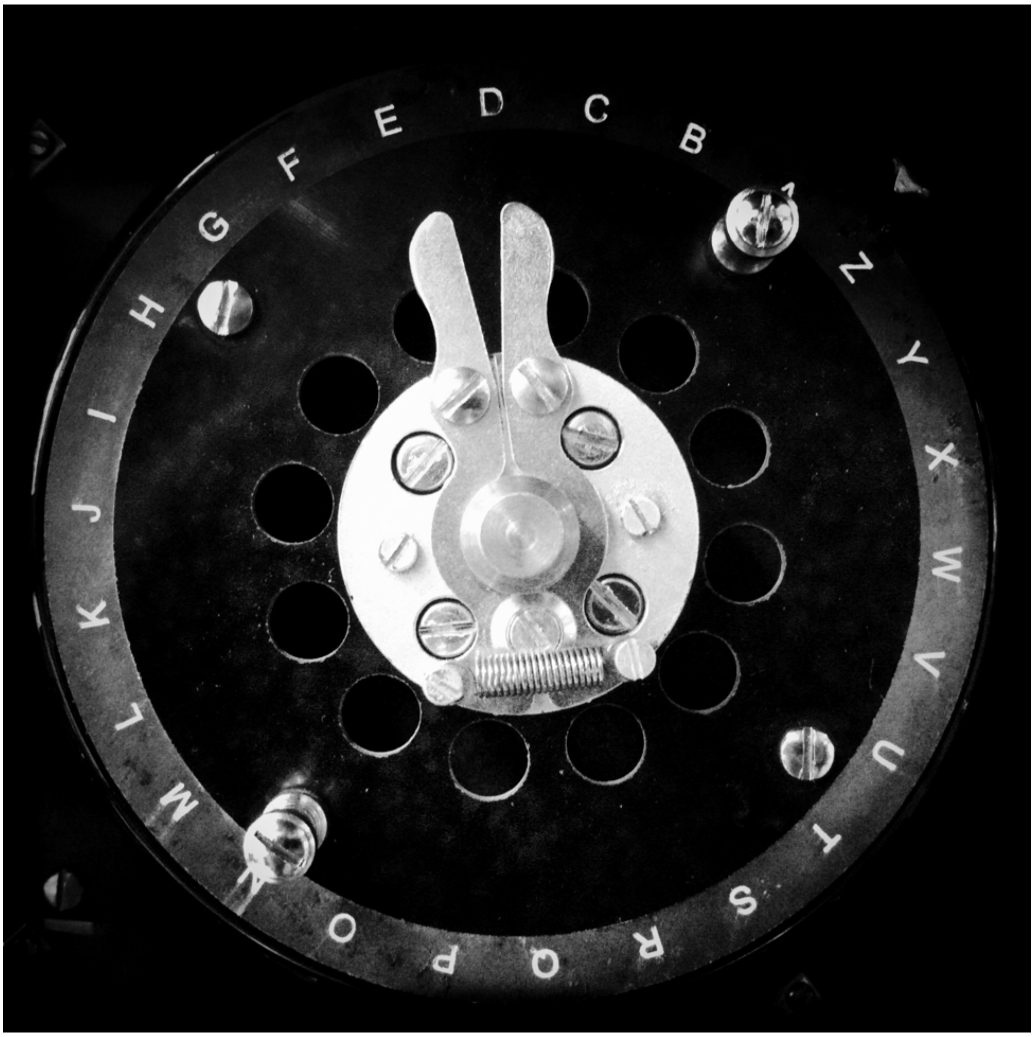

Fig. 4 A single rotor from a 'Bombe' designed by Alan Turing, 1941

[18] Andrew Hodges, *Alan Turing: The Enigma* (London: Randomhouse, 1983), p.318

[19] Alan Turing, 'Computing Machinery and Intelligence', *Mind*, 29 (October 1950), 433-460.

Chapter II

Early Artificial Intelligence

To establish what Artificial Intelligence (AI) actually is, seems at first glance fairly obvious: an intelligence that is artificial. However consider how one would define a concept like intelligence, and certainly we must agree this is quite difficult to explain. To give, for instance, a satisfactory explanation of the concept of intelligence, there is an immeasurable volume of articles and research one must refer to, and finally conclude that there is no solid definition.[20]

There is also, in the history of Artificial Intelligence (as much with the public as with the scientist involved), every now and again, a periodical hubris whenever achievements are made. This in general, is upheld by theories that promulgate AI and, in my opinion; leave little room for critical consideration as to the feasibility of actually producing 'strong' AI in reality. That is to build machines whose overall intellectual ability is indistinguishable from that of a human being.[21] ***It is in my opinion therefore necessary to investigate and even scrutinize how facts, fiction and theory relate to actual working programs.***

[20] Randall Davis, 'What Are Intelligence?And Why?', *AAAI*, spring edition (1998), p.92

[21] http://www.alanturing.net/turing_archive/pages/reference%20articles/what%20is%20ai.html [accessed 19 August 2016)

Fig. 5 Universal Automatic Computer Model (UNIVAC) II, 1958

2.1 *Cold War and the rise of the computers*

The end of the Second World War marks the beginning of the Cold War (1947-1991). A state of military, political and economical tension between the Western Block (United States and NATO allies) and the Eastern Block (Soviet Union and its satellite states), that lasted until the mid-1990s and ended with the disintegration of the USSR.[22] It also marked the ending of a generation. Specifically, the First-Generation computers that were designed for a single task and had no operating system at all.

It was in this period, that the computer was coming out of the wartime laboratory and into a new world, a world standing on the brink of yet another war: a nuclear one. This was the dawn of the Second-Generation computers. Computers such as the UNIVAC built by the Eckert-Mauchly Computer Company, the previously mentioned Manchester Mark 1, designed by Newman and Turing and the IBM 701. All were electronic stored-programme computers and in the market within five years after the war.[23] Although not in any way similar to the market for technology as we know it today, it was, nevertheless, the first time the general public became aware that there was in fact such a thing as a computer.

We must see the development of Artificial Intelligence in light of these historical events. For most key figures involved with the development of the Second Generation computers stood also at the cradle of Artificial Intelligence (i.e. Turing, von Neumann). Also the endowments of the US government granted after the war, to produce computers with increased speed and storage space, made research and development within the field of AI possible.

2.2 *Giant Brains or Machines that Think*

The fact that military influence was predominant in the research and development of computer technology did not elude the public. The general view was, that this new concept of ‘the computer’ was closely related to militarism,

[22] John Lewis Gaddis, *The Cold War a New History* (New York: Penguin Books, 2005), p.1

[23] Jack Copeland, *The Essential Turing: Seminal Writings in Computing, Logics*, *Philosophy, Artificial Intelligence and Artificial Life, Plus The Secrets of Enigma*, (Oxford: Clarendon Press, 2004), p.16.

and technocratic modes of thought. Prevailing sentiments against technology, and what it stood for, spread. Existential humanism was on the rise, popularizing human individuality and authenticity. During the counter-culture in the early 1960s, emerging social critics such as Herbert Marcuse (1898-1979) and Jacques Ellul (1912-1994), advertised techno-anxiety and visions of mechanized dystopias.[24] Lewis Mumford (1895-1990) wrote in his book *Art and Technics* (1952) that:

> Favourable to the cultivation of the inner life and the production and enjoyments of the arts, we find ourselves more absorbed that ever in the process of mechanization. Even a large part of our fantasies are no longer self-begotten: they have no reality, no viability, until they are harnessed to the machine.[25]

In the early 1960s, we see an increased anthromorphization of the computer. In many ways adding to the anxiety and apprehension, acerbated by popular culture. A culture that now held great fascination with computers, robots and other related themes. Popular entertainment at the time, were movies such as *Desk Set* (1957)[26] starring Spencer Tracy and Katherine Hepburn, as well as Edmund C. Berkeley's book *Giant Brains or Machines that Think* (1949), in where we can find this excerpt:

These new machines are called sometimes mechanical brains and sometimes sequence-controlled calculators and sometimes by other names. Essentially, though, they are machines that can handle information with great skill and great speed. And that power is very similar to the power of a brain.

These new machines are important. They do the work of hundreds of human beings for the wages of a dozen. They are powerful instruments for obtaining new knowledge. They apply in science, business, government, and other activities. They apply in reasoning and computing, and, the harder the problem, the more useful they are. Along with the release of atomic energy, they are one of the great achievements of the present century. No one can afford to be unaware of their significance.[27]

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[24] Taylor D. Grant, *When the Machine Made Art: the Troubled History of Computer Art* (New York/London: Bloomsbury, 2014), p.39.

[25] Lewis Mumford, *Art and Technics* (New York: Columbia University Press, 1952), p.6

[26] *Desk Set*, dir: Walter Lang, 1957

[27] Edmund C. Berkeley, *Gaint Brains or Machines that Think* (New York: Wiley, 1961), p.vii.

It is very obvious that the ideas advertised above, the notion that the power of a computer is very similar to the power of the human brain, or even a ‘giant’ brain, was highly appealing and possibly terrifying for a person from the 1950s. It was (and still is) in fact incorrect. Even today, computers are not in any way intelligent or functioning, in comparison, like human brains.

2.3 *The Turing test*

Similar to Turing, as demonstrated in his article *Computing Machinery and Intelligence,*[28] he, Berkeley and others, share a strong belief in the possibility of programming an electronic computer to behave intelligently. Most of their writings however are hypothetical treatises, the Turing-test being a prime example.

The test proposed by Turing in this article, is in fact a kind of ‘game’. In his ‘imitation game’, as Turing calls it, a computer/Turing machine (A) and a human being (B) are being questioned by a human interrogator (C). Both A and B are placed in separate rooms unseen by the interrogator. The answers from either A or B are printed, so that there is no direct contact. The game is a way for the interrogator to determine if he or she is in communication with either a human or a computer. If the interrogator cannot identify the human from the computer, the computer wins. According to Turing If a computer would ‘pass’ the test, then surely it must be ‘intelligent’.[29]

The Turing test has been enormously influential and percolated into the mainstream, even being the subject of several block-buster movies, like for instance Stanley Kubrick’s *2001, a Space Odyssey* (1968)[30] and the neo noir dystopian action thriller featuring Will Smith titled *I, Robot (2004)*[31] based on the works of Isaac Asimov (1920-1992).

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[28] Alan Turing, ‘Computing Machinery and Intelligence’, *Mind*, 59 (October 1950), 433-460.

[29] Alan Turing, ‘Computing Machinery and Intelligence’, *Mind*, 59 (October 1950), 433-460.

[30] *2001, A Space Odyssey,* dir: Stanley Kubrick, 1968.

[31] *I, Robot*, dir: Alex Proyas, 2004.

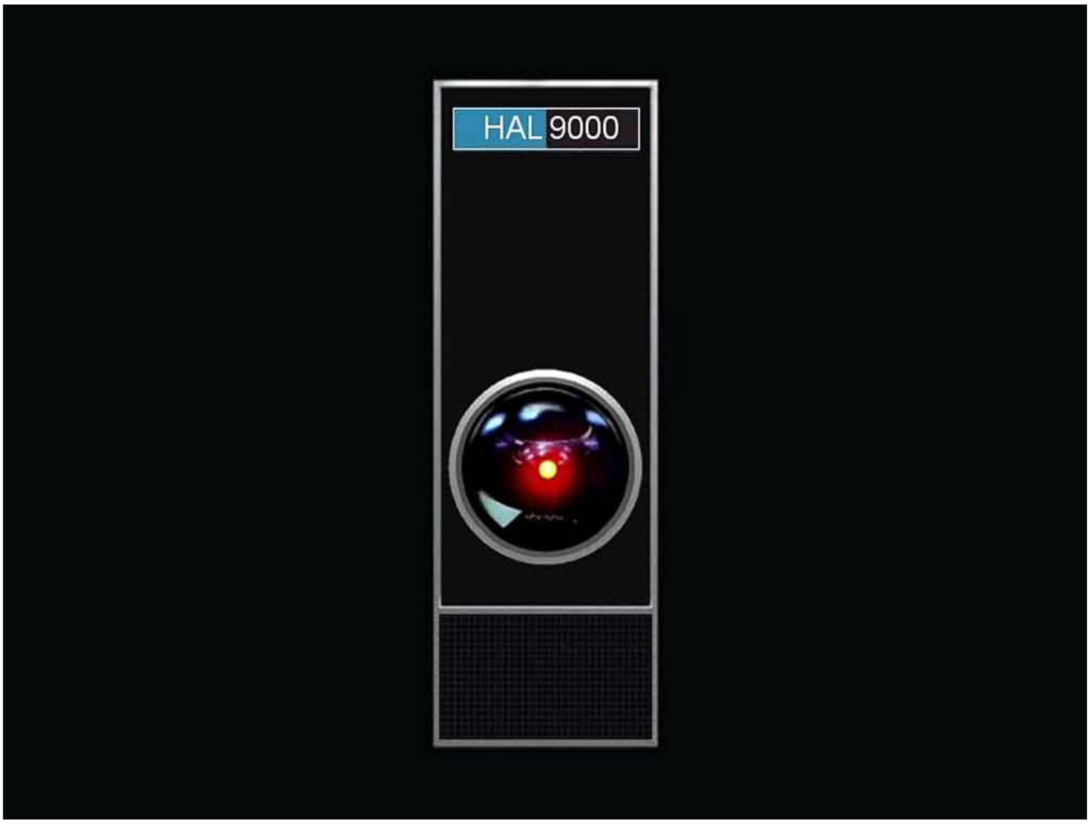

Fig. 6 Artificial Intelligence as portrayed in *2001 a Space Odyssey by Stanley* Kubrick, 1968

Fiction and theory are off course very different from reality. And the Turing test was a way to create a discourse around the subject of thinking machines, and certainly not a true account of a computer matching humans' intellectual abilities. Philosopher Jack Copeland (born 1950) writes: 'Indeed, because they are abstract machines, with unlimited memory, they are capable of computations that no actual computer could perform in practice'.[32] According to AI scientist Bruce Buchanan (born 1940), in reality, early AI programs in the 1950s and 1960s 'were necessarily limited in scope by the size and speed of memory and processors and by the relative clumsiness of the early operating systems and languages.'[33] And writer of one of the seminal histories on Artificial Intelligence, Pamela Mccorduck (born 1977) writes in her book that AI was '[…] an idea that has pervaded Western intellectual history, a dream in urgent need

[32] Jack Copeland, *The Essential Turing: Seminal Writings in Computing, Logics*, *Philosophy, Artificial Intelligence and Artificial Life, Plus The Secrets of Enigma*, (Oxford: Clarendon Press, 2004), p.7.

[33] Bruce G. Buchanan, 'A (Very) Brief History of Artificial Intelligence', *AI Magazine*, 26 (2006), p.56

of being realized'.[34]

Regardless there was a sheer optimism within the nascent AI community, as they held their first conference at Darthmouth in 1956, where they engaged in ideas and demonstrated newly written programs and created the first manifesto for AI that stated: 'Every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it.'[35] And although the first generation of AI researchers discovered and implemented most of the basic principles of programming languages, connectionist learning, data bases, data compression, semantic networks, Bayesian modelling, and so on, the vision of one of the early founders of AI, Marvin Minsky (1927-2016) that: 'Within a generation, the problem of creating artificial intelligence will substantially be solved'[36] remains unfulfilled.

One of the reasons that progress in AI research is relatively slow, even to this present day, is that the all-embracing concept of human intelligence is inherently difficult to translate into a computer program. The multitude of definitions given of intelligence is a fair indicator that there might never be a unilateral understanding of intelligence. If there is to be anything like strong AI, as defined above, a principal challenge for AI is to encompass a vast array of attributes associated with human intelligence like; learning, cognition, reason, creativity etc. and to translate this into a computer program.

Approaching the richness of human associative memory, and identifying our values and of expressing them in computational form, seem even to this day impossible. However, when we proceed with this investigation we must not dismiss the possibility that a computer can be creative beforehand. We must view the arguments proposed by the artists or individuals presented in the case studies with an open mind, but to nevertheless proceed with caution because of the lack of solid ground in these matters.

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[34] Pamela Mccorduck, *History of Artificial Intelligence,* (San Francisco: Taylor & Francis,1977), p.xii

[35] John Mccarty, Marvin Minsky and others, 'A Proposal for the Darthmouth Summer Research Project on Artificial Intelligence', *AI Magazine*, 27 (1955), p.1.

[36] Duco A. Schreuder, *Vision and Visual Perception, The Conscious Base of Seeing,* (Bloomington: Archway Publishing, 2014), p.419.

Chapter III

A Case Study: *Computer Compositions With Lines* (1965)
By Michael A. Noll

Located in a huge building on Mountain Avenue in Murray Hill, New Jersey, a few decades before the mass-migration of technology companies to Silicon Valley, was Bell Laboratories, one of the largest most innovative scientific organizations in the world.[37] The company truly had innovation in its DNA. It was founded as the research arm of AT&T in 1907, since then, it produced thousands of engineering innovations, like for instance the first synchronous-sound motion-picture system. In 1937 scientist form Bell Labs were awarded the Nobel Prize for physics for inventing the transistor and in the 1960s the first satellite communications system also came from Bell scientists.[38]

Bell Labs was an unique environment that provided the opportunity for scientist and engineers to be free in their research and develop projects, that could possibly not have been done elsewhere. It was here that the transition between science and media art began.[39] Noll writes:

> Management at Bell Labs defended and supported research in computer graphics and also music and art. William O. Baker was vice president, research, and he

[37] Taylor D. Grant, *When the Machine Made Art: the Troubled History of Computer Art* (New York/London: Bloomsbury, 2014), p.31.

[38] https://www.britannica.com/topic/Bell-Laboratories [accessed 25 August 2016]

[39] https://www.youtube.com/watch?v=fDQEQPKV8YA [accessed 25 August 2016]

> more than anyone else was responsible for the environment within the research area at Bell Labs. Research was only about 5 percent of the total R&D effort at Bell Labs – but its impact was considerable.[40]

During this period, in the summer of 1962, Michael Noll worked as an intern. He shared an office with his colleague Elwyn Berlekamp (born 1940). One day, Berlekamp came down the hallway with a computer-generated plot of data, which had gone astray because of some programming error. A multitude of lines formed a chaotic pattern on the paper. Both scientists joked about the abstract computer art that they had inadvertently generated, Noll: 'It then occurred to me to use the computer, an IBM 7090, and the Stromberg Carlson plotter to create computer art deliberately. Thus my experiments in computer art began in the summer of 1962 at Bell Labs.'[41]

3.1 *Computer Composition With Lines*

Three years later Michael A. Noll's work was on the cover of *Computers and Automation.*[42] The magazine (later to be called *Computers and People*) was a trade journal, covering developments in computer science. It was the first to hold a competition for any artistic drawing or design created by a computer. The submissions of this 'Computer Art Contest', where placed in the magazine annually. They were described in the magazine as 'beautiful' and 'art' by the editor, Edmund C. Berkeley (who was, as mentioned earlier, a great admirer of the potential of these 'mechanical brains'). As a result Berkeley propelled these computer-generated images toward the discourse of art.[43]

The work created by Noll, titled *Computer Composition with Lines* (1965), was characterized in *Computers and Automation* magazine as follows:

> The positions of the vertical and horizontal bars have been chosen at random with the constraint that the positions must fall inside the circle. The length and width of

[40] Michael A. Noll, 'First-Hand: Early Digital Art At Bell Telephone Laboratories', Inc, *Leonardo*, 49 (2016), 55-65.

[41] Michael A. Noll, 'The Beginnings of Computer Art in the United States: A Memoir', *Leonardo*, 27 (1994), p.39.

[42] Edmund C. Berkeley, 'The Annual Computer Art Contest of "Computers and Automation"', *Computers and Automation,* 14 (1965), p.1.

[43] Taylor D. Grant, *When the Machine Made Art: the Troubled History of Computer Art* (New York/London: Bloomsbury, 2014), p.27.

> the bars was chosen at random within a specified range. If the position of the bar fell within a parabolic region in the upper half of the circle, the length of the bars was shortened by a factor proportional to the distance of the position from the edge of the parabolic region…[44]

This somewhat prosaic description for a work of art, did not however explicate the full narrative behind the work. Noll's *Computer composition with Lines* was in fact a kind of test. To be more precise, a 'crude approximation' on the Turing test (see *2.3.* for description).[45]

The work itself was based on Piet Mondrian's (1872-1944) *Composition with Lines,* made in 1917, as is referred to in the title. It seems that Noll's hypothesis was: that a machine could effortlessly copy Mondrian's works, and no one would know the difference. By doing so *Computer composition with Lines* was made not only to prove this hypothesis but also to emphasize the significance of computers as a creative medium.

Noll entertained the notion that probably*,* Mondrian followed some scheme or program in producing the painting.[46] He was however unaware that the contrary was true. Although the grid-like works look cerebral and schematic, Mondrian's works are in fact the epitomes of intuition instead of mathematics.[47] Nevertheless, a similar image like the structural black and white patterns of Mondrian was eventually generated.

Noll took xerographic copies of both the original (albeit in reduced detail) and the one generated by the computer, and showed these to one hundred subjects. His experiment was to ask each subject which of the two they preferred aesthetically. Eventually fifty-nine out of one hundred subjects preferred the computer composition.

This experiment, largely set in within the framework of the 'man-versus-machine' paradigm of artificial intelligence in the late 1950s, questioned the belief that intelligence and creativity were exclusively the domain of man, and therefore also could possibly undermine the position of the artist. At the time,

[44] Edmund C. Berkeley, 'The Annual Computer Art Contest of "Computers and Automation"', *Computers and Automation,*14 (1965), p.10.

[45] Michael A. Noll, 'The Digital Computer As a Creative Medium' *IEEE SPECTRUM Magazine*, 4 (1967), p.89.

[46] Michael A. Noll, 'Human or Machine: A Subjective Comparison of Piet Mondrian's "Composition with Lines" (1917) and a Computer-Generated Picture', *The Psychological Record*, 16 (1966), p.1.

[47] Isabella Alston, *Mondrian*, (Charlotte NC: TAJ Books International, 2014), p.10.

the novelty of computer technology caused the experiment to be widely publicized. Writers, critics and art-critics were unsure what to think of the proposition posed by Noll. Stuart Preston (1915-2005) wrote that in the future '[…] any kind of painting to be computer-generated […]'[48]

The results of this experiment by Noll remain however, questionable. Because, as mentioned above, the image provided of the Mondrian painting was, very reduced in detail. One could argue without difficulty if this copy could in fact be considered a work by the Dutch master. Also sixty-one out of one hundred participants in the experiment were technicians. Only thirty-one were not, but out of this group only one of the participants was male. Also, in the research results presented by Noll, he wrote:

> Apparently the non-technical Ss very strongly thought that computers would produce mechanical, orderly pictures, and hence a large percentage of the nontechnical Ss were fooled into incorrectly identifying the Mondrian as being the computer picture.' Whereas 'The technical Ss, however, were somewhat more sophisticated and as a group tended to disregard the differences in randomness between the two pictures with the result that their identifications were closer to pure guessing.[49]

In the same year, John Pierce (1910-2002) wrote in Playboy magazine in an article titled *Portrait of The Machine as A Young Artist* (1965), in regards to the outcome of the experiment that:

[…] people who said they disliked or where indifferent to modern art were equally divided in preferring the computer picture or the Mondrian: but people who said they liked modern art preferred the computer picture three to one. I whether this is overestimating the computer's artistic abilities or underestimating Mondrian's.[50]

[48] Taylor D. Grant, *When the Machine Made Art: the Troubled History of Computer Art* (New York/London: Bloomsbury, 2014), p.58.

[49] Michael A. Noll, 'Human or Machine: A Subjective Comparison of Piet Mondrian's "Composition with Lines" (1917) and a Computer-Generated Picture', *The Psychological Record*, 16 (1966), p.8.

[50] John Pierce, 'Portrait of The Machine As a Young Artists', *Playboy Magazine*, June (1965), p.150.

Fig. 7 Piet Mondrian, *Composition With Lines*, 1917 and Michael A. Noll, *Computer Composition With Lines,* 1965

3.2 *Randomness*

But to what extend was the computer in its own right responsible for the creation of the *Computer composition with lines?* Noll created the programs structure, the underlying algorithms based on the pattern imagined by Mondrian. Was the computer left to it's own device? Maybe to a certain degree, but it remained under the supervision of the artist-programmer. It was a trial-and-error process designed to approximate a certain pattern. The images generated that did not show similarity to Mondrian's composition were discarded and the process would start anew.[51]

A dose of randomness to transform otherwise unimaginative competent thinking into creative thinking, is a fairly attractive supposition. Computer scientist in Darthmouth cultivated this assumption.[52] However computer programs based on random algorithms, like the one Noll used to create *Computer composition with lines,* appear to us as random, but are in fact pseudo-deterministic.[53] As for determinism in relation to human creativity, one could argue that it is, as is the whole of the universe, others claim we do have a capacity for agency. But human creativity nevertheless remains an extremely sophisticated process, which seems very difficult to define as just randomness.

Noll himself was very clear on the matter, that 'Both patterns were conceived by humans, although certain features of the computer-generated picture were decided by a programmed random algorithm.'[54] Although he did in many articles propagate the prodigious abilities of the computer, never did he claim the computer to be autonomous in the creative process. Much of what he believed would be the role for the computer in the future revolved around a profound relationship between the 'artist-programmer' and the computer. In which the computer actively would take over some of the artistic processes, and through random algorithm providing the artist with new paths to follow.[55]

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[51] Michael A. Noll, 'Computers and the Visual Arts', *Design Quarterly,* 66/67 (1967), p. 70.

[52] John Mccarty, Marvin Minsky and others, 'A Proposal for the Darthmouth Summer Research Project on Artificial Intelligence', *AI Magazine*, 27 (1955), p.1.

[53] Michael A. Noll, 'The Beginnings of Computer Art in the United States: A Memoir', *Leonardo*, 27 (1994), p.41.

[54] Michael A. Noll, 'Human or Machine: A Subjective Comparison of Piet Mondrian's "Composition with Lines" (1917) and a Computer-Generated Picture', *The Psychological Record*, 16 (1966), p.9

[55] Michael A. Noll, 'The Digital Computer As a Creative Medium' *IEEE SPECTRUM Magazine*, 4 (1967), p.89

Chapter IV

A Case Study: *AARON* (1973 – ongoing) by Harold Cohen

The early 1970s, until approximately the late 1980s, saw stagnation of funding and interest in AI related research and development projects. This was mostly due to amplified expectations to what AI could actually do.[56] As was mentioned earlier, some of the most prominent AI researchers such as Marvin Minsky (see 2.3), made bold predictions that were hard to live up to. AI was far from delivering working systems that matched the unrealistic promises. Disappointed by the lack of progress, funding agencies like DARPA curtailed their investments in AI.[57] Criticism against AI research soon followed.

Pressured by dwindling funds and growing critique, scientist moved towards a different approach to AI. It was to abandon strong AI and to create more specific systems for more specific problems. These were the so-called 'expert systems'. Instead of a procedural programming, through which the computer simply has a series of step-by-step procedures to execute, the expert system was knowledge based, consisting of a vast collection of symbols and rules provided by its programmer.[58] It could

[56] Nils Nilsson, *The Quest for Artificial Intelligence* (Cambridge: Cambridge University Press, 2009), p.408.

[57] Nils Nilsson, *The Quest for Artificial Intelligence* (Cambridge: Cambridge University Press, 2009), p.409.

[58] Alex Roland, Philip Shiman, *Strategic Computing: DARPA and the Quest for Machine Intelligence, 1983-1993* (Cambridge MA: The MIT Press, 2002), p.192.

make decisions based on this knowledge, thus simulating a sense of reason. Expert systems soon became AI's first commercial success, for it could be used to solve a great variety of problems and drastically improve efficiency in various commercial fields.[59]

4.1 *What is AARON?*

AARON can draw. It appears to have a sense for the anatomy of the human body. AARON can portrait persons, depict plants and doodle an unlimited amount of abstract patterns. It knows about perspective. Placing figures in jungle-like surroundings, in between pots filled with flowers on pedestals. It has a sense of colour. Its palette consists of every possible hue in different gradients of brightness. AARON can produce innumerable unique paintings in the same moderate pace over and over again.[60]

AARON is in fact an expert program, written by Harold Cohen (1928-2016) in the late 1960s with a single purpose: to replicate elements of creative human behaviour.[61] Its 'artistic' development was slow and incremental. For over forty years every single technique was painstakingly programmed, making it the oldest continuously developed program in computing history.[62] In its early years, AARON could hardly distinguish a figure from the ground.[63] In the 1990s, AARON possessed all the knowledge and understanding it needed to complete a full-coloured painting.[64]

Since its early years of development, AARON's work has been exhibited numerously and publicized the world over. It left audiences puzzled by its animated drawing arm hovering over the paper, 'thinking' as where to make its next mark,[65] although AARON itself, has no notion of this outside world

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[59] Peter Norvig, Russel Stuart, *Artificial Intelligence a Modern Approach* (New Yersey: Prentice Hall, 1995), p.22.
[60] Harold Cohen, 'The Further Exploits of AARON, Painter', *SEHR,* 4 (1994) p. 1-13.

[61] Harold Cohen, 'Driving the Creative Machine', *Crossroad Lecture series at the Orcas Centre*, September (2010) p.1.

[62] Harold Cohen, 'The Further Exploits of AARON, Painter', *SEHR,* 4 (1994) p. 1.

[63] Harold Cohen, 'The Further Exploits of AARON, Painter', *SEHR,* 4 (1994) p. 1.

[64] Taylor D. Grant, *When the Machine Made Art: the Troubled History of Computer Art* (New York/London: Bloomsbury, 2014) p.131.

[65] Taylor D. Grant, *When the Machine Made Art: the Troubled History of Computer Art* (New York/London: Bloomsbury, 2014) p.132.

whatsoever. The program does not have any input besides the rules and facts it got from its creator. AARON's cognitive world is based in its memory; each single work produced by the program was '[…] made by considering what it wanted to do in relation to what it had done already.'[66]

4.2 *In-depth examination of AARON's systems*

Like any expert system, AARON works on two sub-routines. The first is the *knowledge-based system*. AARON needs 'expert-knowledge' to function. Specific knowledge is necessary to produce specific results. So what exactly is this 'expert-knowledge'? Well that depends on the problem. In the case of a computer program that is designed to paint pictures like AARON, the information that has to be programmed, are basically parameters formulating how to create an image. The parameters can be defined as *if-then rules*. That means that *if* a certain situation occurs, *then* AARON has a set of options to choose from within a certain framework, and so it does randomly.

The application of the *if-then* rules is done by the second subroutine of the expert system, called the *inference engine.* It is also responsible for subsequently feeding back the latest result back into the system and iteration[67]. As described by Cohen:

> '[…] the system (AARON) should properly be considered as an iterative processor of ingenious design, in which the complexity of the result stems from the iteration rather that from the process itself'.[68]

This so called 'feedback mode', makes it possible for AARON to develop new images infinitely, even without the interference of a programmer. Unlike computer-generated Images that are created as result of pre-determined transformations upon a set of data provided by a human, like mentioned in the previous chapter, AARON was able to randomly generate images on it own,

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[66] Harold Cohen, 'The Further Exploits of AARON, Painter', *SEHR,* 4 (1994) p.2.

[67] Janet Finlay, Alan Dix*, An Introduction to Artificial Intelligence* (London: CRC Press, 1996), p.123.

[68] Harold Cohen, 'Parallel to Perception; Some Notes on the Problem of Machine-Generated Art', *Computer Studies*, 4-3-4 (1973) p. 6.

through it's own input. So instead of just being a 'picture-processor', AARON appears to be able to build new work from its own oeuvre just like a human artist would and 'develop' over time. Cohen writes:

> *Human art-making behaviour is characterized by the artist's awareness of the work in progress, and programs to model such behaviour will need to exhibit a similar awareness. Thus, 'behavioural functions' are defined here as functions which require feedback from the results of their actions as a determinant to their subsequent actions.*[69]

4.3 *The artist*

Programming these kinds of expert systems were cutting edge in the late 1960s, and so very unlikely for a person like Harold Cohen to advance in this kind of field. Because Cohen, unlike many other artist-programmers, already had build up a fairly successful artistic career, representing the United Kingdom at the Venice Biennale of 1966.[70] Works made by Cohen himself, are now part of the Tate Gallery collection.[71]

It was a 'random event', as Cohen puts it,[72] which led him on a path that would govern his career for more than half of his life. His transfer from Slade School of Fine Art, London, to the newly established Visual Arts department at University of California, San Diego, introduced him to computing in 1968. However, back then, programming was a tedious affair. One would need IBM cards for every operation that could take hours even days to complete. Cohen nevertheless, was driven by a notion that making art did not have to '[…]require ongoing, minute-by-minute decision making – the unquestioned, "normal" mode – and that it should be possible to devise a set of rules and then, almost without thinking, make the painting by following the rules.'[73]

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[69] Harold Cohen, 'Parallel to Perception; Some Notes on the Problem of Machine-Generated Art', *Computer Studies*, 4-3-4 (1973) p. 1.

[70] Harold Cohen, 'Driving the Creative Machine', *Crossroad Lecture series at the Orcas Centre*, (September 2010) p.3.

[71] http://www.tate.org.uk/art/artists/harold-cohen-925 [accessed 4 September 2016]

[72] Harold Cohen, 'Driving the Creative Machine', *Crossroad Lecture series at the Orcas Centre*, (September 2010) p.3.

[73] Harold Cohen, 'Driving the Creative Machine', *Crossroad Lecture series at the Orcas Centre*, (September 2010) pp.3-4.

4.4 *Relationship*

His initial convictions changed over time. This off course is not unimaginable, since forty years is a considerable duration in which most people, especially artists, change course, develop and innovate in the duration of their lives. And as Harold Cohen considered new avenues, so did AARON go through transitions that corresponded with Cohen's contemplations. AARON's drawing techniques became more refined during several decades, and rules where meticulously programmed so that certain objects could overlap without being intersected.

Introducing colour in AARON's work for instance was something that Cohen, as a colourist, took very personal. It took him a great amount of self-reflection to consider himself how colour could be implemented in the form of an absolute code. As Cohen put's it: 'It began with me recognizing myself – and the program- to be in a dead-end situation and thus being forced to step back and to reconsider the entire enterprise'.[74]

Cohen's connection to AARON was in a sense to be regarded as an intimate relationship that grew over time, only ending with the death of the creator (Cohen died in 2016). This is something that must not be overlooked, since the aspect of human-computer relations is essential in understanding the questions of authorship and autonomy in this regard. Obviously AARON is painting the works, Cohen however designed AARON to do so in a very specific way. Could AARON produce anything without any input? According to Cohen '[…] it is not possible to run a program from scratch without providing it initial material'.[75] Is then AARON at least creative? According to Professor of cognitive science at the Univestity of Sussex, Margareth Boden (born 1936):

> AARON cannot reflect on its own productions, nor adjust them as to make them better. It cannot even transform its conceptual space, leaving aside the question of whether this results in something "better". In this, it resembles most current AI-

[74] Harold Cohen, 'Driving the Creative Machine'*, Crossroad Lecture series at the Orcas Centre*, (September 2010) p.9.

[75] Harold Cohen, 'Parallel to Perception; Some Notes on the Problem of Machine-Generated Art', *Computer Studies*, 4-3-4 (1973) p. 6.

programs focused on creativity.[76]

It is interesting to distinguish the different attitudes and strategies that Cohen conceived during his decade long relationship with his machine. In his final stage of transformation, AARON was programmed by Cohen to resemble a 'natural' system, rather than an 'intelligent' system. Being stripped of purpose, if it ever had any.[77] For Cohen, he believed that in its artistic endeavours, in AARON's subroutine, intelligence was not relevant anymore.[78] His notion that one day computers would be able to imitate human creative abilities, such as he hinted in his paper *Parallels to Perception* (1973), he in later life gradually shifted to a more austere notion that working with AARON was more like a dialogue or even an symbiotic relationship. That AARON was itself creative however, he vigorously denounced: 'Art is an activity requiring self-awareness: computers cannot be aware of themselves: therefore computer programs cannot make art.'[79] Leaving no question as where the authorship lies: 'I give the machine its identity, it is doing what I have in mind.'[80]

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[76] Margareth A. Boden, 'Creativity and artificial intelligence', *Artificial Intelligence Magazine*, 103 (1998), p.347-356.

[77] Harold Cohen, 'The Art of Self-Assembly: the Self-Assembly of Art', *Dagstuhl seminar on Computational Creativity* (2009), 6 < http://www.aaronshome.com/aaron/publications/dagpaper.odt>

[78] Harold Cohen, 'The Art of Self-Assembly: the Self-Assembly of Art', *Dagstuhl seminar on Computational Creativity* (2009), 6 < http://www.aaronshome.com/aaron/publications/dagpaper.odt>

[79] [79] Harold Cohen, 'The Art of Self-Assembly: the Self-Assembly of Art', *Dagstuhl seminar on Computational Creativity* (2009), 6 < http://www.aaronshome.com/aaron/publications/dagpaper.odt>

[80] Pamela Mccorduck, *Aaron's code: Meta-Art, Artificial Intelligence, an the Work of Harold Cohen* (New York: W.H. Freeman, 1991) p.40.

Fig. 8 AARON, *Aaron With Decorative Panel*, 1992

Chapter V

A Case Study: *DEEPDREAM* (2015) by GOOGLE

During the 1990s we see a substantial shift of content and methodology within the AI-field.[81] Symbolic processing (like AARON), as propagated by logistic theorists like Allen Newell (1927-1992) and Herbert A. Simon (1916-2001), John Mccarthy (1927-2011), Marvin Minsky (1927-2016) and others, was still the dominant proposition until the late 1980s, for obtaining strong AI.[82] It proposed that symbol manipulation was the essence of both human and machine intelligence. For they believed that the human mind can be viewed as a device operating on bits of information according to formal rules.[83] These 'bits of information' can be defined as symbols, in AI-terminology these are high-level symbols (see 1.4) such as 'chair or 'table' etc.

This is a very appealing argument in a Platonian sense off course. Would it not be practical to reduce reality into clear-cut symbols and then feed it into a computer? It is however obvious that this symbolic proposition is inconsistent with real-life human reasoning, as was pointed

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[81] Nils Nilsson, *The Quest for Artificial Intelligence* (Cambridge: Cambridge University Press, 2009), p.419.

[82] Peter Norvig, Russel Stuart, *Artificial Intelligence a Modern Approach* (New Yersey: Prentice Hall, 1995), p.24.

[83] Hubert Dreyfus, *What Computers Still Can't Do* (Cambridge MA: The MIT Press, 1979) p.40.

out by philosopher Hubert Dreyfus (born 1929).[84] An example being, that when we see a chair for instance, we do not per se imagine it to be a four-legged model. Simply put: whereas a symbolic processing system functions on only 'true' and 'false' premises, human reasoning certainly accepts 'maybe' as an answer.

This led AI researchers to search for alternative strategies, for 'rules' that could govern a more unconscious reasoning, strategies that were more suitable for acquiring pattern recognition and linguistic systems.[85] Luckily AI researchers did not have to invent the wheel all over again. The mathematical models that would be the foundation for the most significant achievements in the AI field to date where already in place. It was a radical different approach to AI than top-down orientated symbolic process paradigm.

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[84] Nils Nilsson, *The Quest for Artificial Intelligence* (Cambridge: Cambridge University Press, 2009), p.391.

[85] Luciano Floridi, *Philosophy and Computing an Introduction* (London: Routhledge, 1999), p.170.

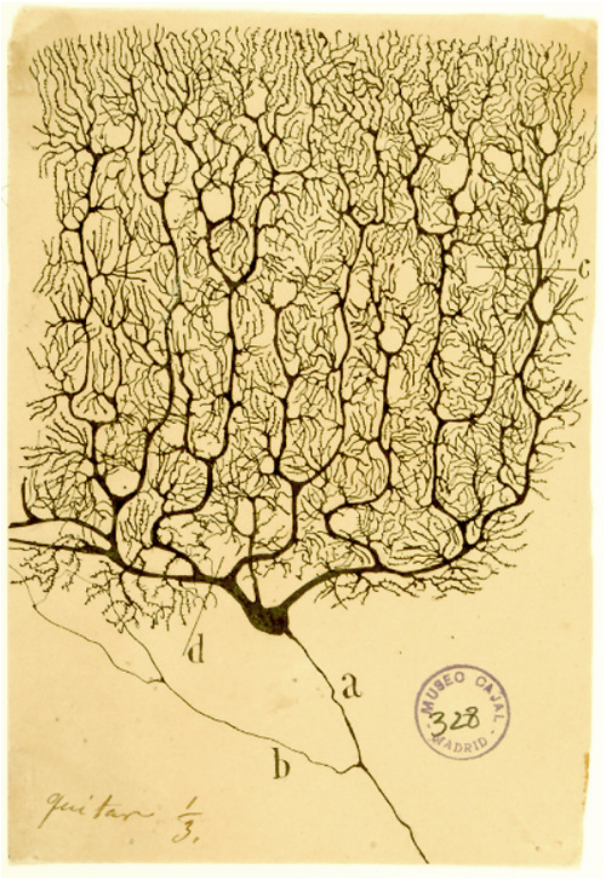

Fig. 9 Santiago Ramon y Cajal, *Neurons,* 1892

5.1 *Rediscovering neural networks*

Images of neurons, axons, and dendrites illustrated by a Spanish neuroscientist named Ramon y Cajal (1852-1934) inspired neurophysiologist Warren Mcculloch (1898-1969) and logician Walter Pitts (1923-1969) as early as 1943, to propose an abstract mathematical model of the first artificial PE (processing element).[86] Based on the idea that neuron activity is an all-or-none process, which can be characterized as an 'on' or 'off' mode, these so-called *artificial neurons* could in fact, in certain configurations, perform the same logical operations that are carried on by a Turing-machine.[87]

> They showed, for example, that any computable function could be computed by some network of connected neurons, and that all the logical connectives could be implemented by simple net structures. McCulloch and Pitts also suggested that suitably defined networks could learn. Donald Hebb (1949) demonstrated a simple updating rule for modifying the connection strengths between neurons, such that learning could take place.[88]

Later psychologist Frank Rosenblatt (1928-1971) embroidered further on Mcculloch and Pitts' work, developing the 'perceptron', a network of Mcculloch-Pitts style neurons, in which the output of one element are inputs to others. By doing so Rosenblatts work '[…] was responsible for initiating one of the principal alternatives to symbol-processing methods in AI, namely, neural networks'.[89]

Rosenblatt's networks where however inadequate to model specific patterns and limited in scope, as was described in Minsky's and Papert's book *Perceptron (*1969). Unfortunately for Rosenblatt, this book meant a devastating blow for neural networks research. Interest in the field dropped significantly, and symbolic-processing again seemed the way forward.

Not until the mid-1980s did neural network again resurface. This was due mainly to the more sophisticated algorithms that by now were available, as well as the increase in computer capacity. This period of so-called neo-

[86] Luciano Floridi, *Philosophy and Computing an Introduction* (London: Routhledge, 1999), p.168.

[87] Luciano Floridi, *Philosophy and Computing an Introduction* (London: Routhledge, 1999), p.168.

[88] Peter Norvig, Russel Stuart, *Artificial Intelligence a Modern Approach* (New Yersey: Prentice Hall, 1995), p.16.

[89] Nils Nilsson, *The Quest for Artificial Intelligence* (Cambridge: Cambridge University Press, 2009), p.92.

connectionism was the starting point for a new generation of neural network systems, as we know them today.

5.2 *Modelling cerebral activity*

Training by back propagation using gradient descent, convolutional deep belief networks for scalable unsupervised learning of hierarchical representations, primitives of an image, maximalization pooling, normalization, rectified linear units and deep stacking are just some of the terminology involved in understanding just a simple deep convolutional neural network. A full discourse on back propagation in convolutional networks, is very mathematical and simply too complex to explicate in this dissertation. Therefore it seems just, to simplify neural networks without omitting off course, the relevant particulars in regards to autonomous computational creativity.

As can be seen in the drawing of Cajal, a neural network in the brain consists of an innumerable amount of neurons. Like mentioned above, Mcculloch's and Pitts'
Model, was inspired on the schematics of a neuron (important to mention is that is does not replicate a human neuron in any way, since it is still very hard to specify how neurons in the human brain actually work). In simple terms, in a Mcculloch-Pitts *artificial neuron* (AN) there is an input, and based on the strength of the input, the AN 'fires' an output, however, if the input is weak, nothing fires at all. That is basically the basis of a neural network. A Rosenblatt *perceptron* is, again like mentioned above, a number of AN's placed in layers in a way, that the output of the first layer determines the input of the second layer. Compared to neural networks, as we know them today, a Rosenblatt perceptron is extremely rudimentary.

Google's *GoogleNet*, for instance, is a deep convolutional classification network that has up to twenty-two layers (deep referring to a number of layers more that two or three). It does what any convolutional network does best, to find patterns. The purpose of *Googlenet* is to classify images. For instance when we give the network a particular image, then *GoogleNet* can classify the image as such and so, based on a certainty rating.

The way it does that is by deconstructing every image that it is being given, in to tiny pieces. Every piece of information is given a certainty rating between 0 and 1 by the AN. A low rating can best be compared to a weak input of an actual neuron hence it does not fire. A high rating does fire and activates an artificial neuron in the second layer, and so on.

In a deep convolution network the characteristics of an image that are being analyzed in the first or lower layers, are very small elements of that particular image, like corners or edges for example, whereas the higher level layers are working with far more sophisticated patterns, like the wings of a bird or the wheel of a car, resulting in a certain conceptual hierarchy in the layers. So as the characteristics of the image are propagated forward through the network, the neurons are looking at the broader scope of the image, as it is trying to interpret the image.

At the last layer, the system is ready to give us a result by approximation. The outcome reflects how certain the network is in its being correct. A certain image for instance could get a certainty rating of 0.92 for the classification of a bird and a 0.12 for car. If in this case the input was the image of a bird, the network seems quite accurate.

In this process, back propagation is an important aspect of a deep convolutional network. Because a nascent neural network is very erroneous as it starts out. It has to be trained to be effective. In this regard, back propagation is a method to fine-tune each neuron to get the best results. It therefore has to be given the correct answers beforehand in order for it to diagnose its own inadequacies. So if for instance, the outcome would be a rating of 0.92 for bird, and considering the rating Is between 0 and 1, then there is still a uncertainty margin of 0.08. The system then goes through every configuration of every single neuron, doing millions of calculations, to make the margin of error as small as possible, until 0.9999 percent of every input is correct. The more images are processed from a certain type, the better the network functions, and it does so autonomously. We consider this process, unlike symbolic processing, a bottom-up approach i.e. we are not telling the computer what the exact definition must be for a particular image, its figuring that out all by itself.[90]

[90] Alex Krizhevsky, Ilya Sutskever, and Geoffrey Hinton, 'ImageNet Classification with Deep Convolutional Neural Networks' (unpublished paper, University of Toronto, 2012), pp.1-9.

Fig. 10 Example of a simplified convolutional network

5.3 *My computer was dreaming*

What Google scientist in the *DEEPDREAM* project (2015) basically did, was to reverse the process. Since *Googlenet* is fully trained on the prominent *ImageNet* dataset, it recognizes more that hundreds of thousands of images of 200 different classes. It differentiates these images through its neural pathways that are stored in the network's memory. So what happens when one would give the network a definition (like bird) and have it construct an image based on its experience, based on the settings of the millions of individual artificial neurons layered in hierarchical order?

The results were quite remarkable. In the example of a bird, the network came up with an agglomeration of birds in a colourful setting. This was apparently what the network associated with the concept of a 'bird'.[91]

This process, now described as *Inceptionism,* is in many ways very different from our earlier case studies. First in that the convolutional network 'learned' through the act of back propagation. It learns to recognize images in very similar way infants do. To show children a bird and tell them over and over again 'this is a bird' we engrain their neural pathways with information. These pathways get stronger as time progresses and the child encounters more birds.[92] Second, in that back propagation is designed for the network to optimize its performance. The network thus has a sense of 'good' and 'bad' performance, whereas a system like AARON, had no reflective capability whatsoever.

Could we then consider a deep convolutional network creative? Is it autonomous? According to Zachary Case Lipton, in regards to the *DEEPDREAM* project, his notion is that:

> [...] we should hesitate before attributing the human virtue of creativity to today's models. Deterministic image generators are fascinating, but exhibit no agency. Stochastic models that produce realistic output might possess something akin to

[91] https://research.googleblog.com/2015/06/inceptionism-going-deeper-into-neural.html [accessed 10 September 2016]

[92] Tomas Paus, Alex Zijdenbos, and Keith,Worsley, 'Structural Maturation of Neural Pathways in Children and Adolescents: In Vivo Study', *Science Magazine*, 283 (1999), p.1908.

> mastery. But for AI to exhibit creativity, it must do more than imitate […]' [93]

However there are less sceptical thoughts on the matter (although the CEO of Imaginations Engines Inc. could be considered biased), Stephen Thalers notion is not unjust, namely that:

> […] there is a point in any reasoning. Once we develop such neural network based systems we attain a purely connectionist paradigm to compare with likewise connectionist neurobiology. After all, we anticipate that all brain function, including creativity, somehow originates in the collective behaviour of neurons. Therefore, if we can attain any degree of originality from these artificial systems using a limited palette of neurobiological analogies such as computational neurons and connection weights then we may more readily make contact and comparisons with brain studies. Attaining these network-based creativity systems we may eventually announce various degrees of success in modelling human inventiveness and then identify exactly what elements are needed to bridge the gap.'[94]

[93] http://www.kdnuggets.com/2016/05/deep-neural-networks-creative-deep-learning-art.html [accessed 13 September 2016]

[94] http://imagination-engines.com/iei_pcai.php [accessed 13 September 2016]

Fig. 11 Google, *DEEPDREAM,* 2015

Conclusion

In the short period of time that Artificial intelligence exists, already it has resulted in some significant research. Contributing to fields as diverse as: neurobiology, linguistics, psychology, philosophy and mathematics, only to name a few. The research done in AI is inherently introspective; researchers within this particular field provide us with insights in to the way we perceive the world around us, by thoroughly analyzing how the human brain works, in order to translate these functions into a computer program.

Artificial Intelligence also has made a profound impact in our daily lives, even if, most of the time, we do not realize this. Many AI-applications have been implemented in search engines, banking and transport systems. Optimizing results, in order to make our world more efficient. But besides all of this, does Artificial Intelligence have a claim to creativity? Does it even come close to such results?

As mentioned before, creativity is a very difficult concept to define. In regards to novelty, one might consider a computer creative to a certain degree. Because it is able to produce new and interesting images, illustrated in the work of Michael A. Noll, there are even certain things a computer can do that humans cannot. As Harold Cohen might agree, a computer could essentially be an enormous asset in an artist's creative process, as a partner, but in his opinion not as an independent creative agent.

If we think of creativity as a deeply relational and associative process however, in where cognition, memory and experience are instrumental as the creative mind is formulating its ideas, then, we must obviously conclude that at up till now AI has not been able to be creative. Although deep convolutional neural networks are marvellous in their ability recognize pictures and even to construe images, from of an infinite maze of self-taught artificial neurons (and this might be a profound leap forward in AI research), nevertheless, it can only perform a single task, one that even infants can do much better. Also the machine has no idea what the significance is as to what the image entails, it has no sense of self, thus AI can not relate to the subject.

Furthermore it has to be programmed to do so. All programs as mentioned in the case study are not autonomous, automatic yes, but autonomous, I am afraid not. For certainly no computer technician ever woke up in the morning to find that its computer has been drawing all night because it felt like doing so.

In my opinion the true creative ability lies in the programmer, like Michael A. Noll, Harold Cohen and the *DEEPDREAM* project team. There is an impressive amount of creativity and inventiveness as well as perseverance, necessary to make these programs do what they do. It would, in my opinion, be a loss to art in general if we do not appreciate programming as an artistic activity.

But most of the accomplishments in the AI field are overshadowed by optimism and hubris. The field has had several setbacks as a result of inflated expectations. In *Aramis, or the Love for Technology* (1996), philosopher Bruno Latour writes:

> The observer of technologies has to be very careful not to differentiate too hastily between signs and things, between projects and objects between fiction and reality, between a novel about feelings and what is inscribed in the nature of things.[95]

Whilst writing this dissertation I took this advice to heart, and if I could I would urge others to do so as well. Because there is a long way to go for a computer to even come close in obtaining something remotely like human creativity.

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[95] Bruno Latour*, Aramis, of The Love of Technology* (Cambridge; London: Harvard University Press,1996), p.24.

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