Turing's creativity and Science Fiction films: Abstractions and hidden layers

Cate Dowd[1]

Abstract. Alan Turing's logic for digital machines and the imitation of other machines, including possibilities with human parts, are reconfigured in numerous Science Fiction films. Machine and human intelligence, including embodiment, are partly shaped by the ebb and flow across Science Fiction and Computer science. Turing's digital concepts and the influence of numerous ideas from Science Fiction films can be better understood firstly via a closer look at the hidden layers and abstractions of digital computers which Turing conceived in 1936. By understanding Turing's binary digits and the convergence of numbers it is possible to see how Turing entertained the notion of digital mimicry of other machines and even humans. The mimicry of human traits since Turing's time is evident in many scientific innovations and abundant in Science Fiction films. Both Science and Science Fiction films perpetuate the idea of 'thinking machines' raised by Turing in a moment of realisation about his binary system for digital computing, that is its flexibility to mimic almost anything. In contemporary time there is as much focus on the integration of intelligence into machines that serve human purposes as there is on activities that aim to distinguish humans from computational machines. Cyborgs, on the other hand, can extend a third hand, arm or ear to improve embodiment, action or art, whilst robots use vision sensors and other sensory systems to mimic human features. Turing was the first to link mimicry of humans using digital machines with cameras and microphones towards the possibility of simulating human senses, an application idea which continued into robotics. These ideas were in addition to his instructions on how digital computers should be set up and run, which later became known as 'computer programming'. The combination of his work and ideas provided the base for Artificial Intelligence and Robotics. In the early 21st century the increasing power of microchips, sensor technologies and machine intelligence, echo Turing's notes on storage, speed and methods for programming digital machines. It was the sum of Turing's work that led him to produce the question 'Can Machines think?' and this paper suggests that Turing's question remains a worthwhile conjecture. The question revisited has new contexts at the intersections of digital technology and media, scientific innovation and Science Fiction films. Turing's foresight of mimicry via his digital computing concepts continues in many diverse applications into the 21st Century.

1 INTRODUCTION

This paper acknowledges the significant abstractions by Alan Turing in 1936 that informed the creation of general-purpose computers. Such computers are distinct from specific-purpose machines even though specific purpose machines combined with electronics motivated Turing towards implementation of his general-purpose, or universal computer abstractions.

A core idea of Turing's for digital machines was the notion that machines could imitate human beings in various ways. Science Fiction films do well at the appearance of machines imitating human beings, but in reality there is a much bigger gap. Sci-Fi films also show advances in science that are not yet popularised and sometimes presents suggestions for scientific research. Then notion of imitating humans via machines is evident in Science Fiction stories before and after Turing's time, from the drama of Rossums's Universal Robots [1] in 1920 to Science Fiction films of the late 20th century, such as *Terminator 2; Judgement Day* [2].

In real world applications, beyond film, machine parts are actually embedded in human beings to replace or simulate various bodily functions. These are Cyborgs as such but experimentation across these areas can inform Artificial Intelligence (AI) research. These intersections open up the dialogue about 'thinking machines' and broad features of technology, embodiment and transformation of the body. The imitation of human 'thinking' is a challenge for AI with different meanings according to ones leanings for either "classic AI or Connectionist AI [the latter] concerned to bring about machine intelligence regardless of whether it resembles human intelligence' [3]. This divide is also present in Science Fiction films and actually began with Turing's somewhat controversial question - 'Can machines think?' [4:433]

Turing explained this question via a game called the Imitation Game, which aimed to explore the possibilities of digital machines imitating and competing with humans, and to consider how machines might learn. There are various versions of the Imitation Game, also referred to as the Turing Test. The imitation of humans by machines is the background for exploring mimicry, embodiment, skin, brain metaphors, consciousness and emotions. It is a discussion with numerous crossovers between Science Fiction films, such as genetically engineered Replicants from the film *Blade Runner* [5] and Turing's ideas for intelligent machinery, including his idea of replicating a human being as a machine.

As part of a new discussion it is useful to bring to the foreground the broad features of Turing's digital computer such as sequences, inputs, storage and search concepts and consider the influences at these levels in Science Fiction films as well as contemporary computer science. These features are relatively hidden layers of Turing's digital machines, alongside more explicit suggestions for using cameras & microphones for imitating human senses as part of machine intelligence. These ideas are visible in fictional machines and central components of robots in the 21st century. The examples in this paper serve as an introduction to programmed behaviour of machines and bring to

[1] School of Arts, University of New England, NSW, Australia.
Email: cdowd2@une.edu.au

the foreground the influence of evolutionary biology, genetic fitness and natural coding on computing and intelligent machinery, all of which began with Turing. In Artificial Intelligence genetic algorithms are used for various purposes, such as the fitness of a synthetic player in a computer game whilst Science Fiction films extend the idea of genetic mutations to rogue machines, which are assumed to be digital machines, even though they are indeed fictional characters.

2 TURING'S ABSTRACTIONS: TOWARDS DIGITAL COMPUTERS

In 1936 Turing wrote a paper titled 'On Computable Numbers, with an Application to the Entschiedungsproblem' [6]. In this paper, not published until 1937, Turing identified that irregular numbers required solutions if they were to be processed via a machine. For this end he worked on mathematical functions to allow for computable numbers, which at that time of his writing, were confined to an abstract machine. Turing's conceptual ideas for 'computable convergence with numbers' [6] was the base for a machine that could process zeros and ones and finite symbols. The abstract machine was conceived as a system of inputs and outputs in which symbols would be scanned, erased and recorded via a tape. Turing described this abstract machine as 'a digital tape, the analogue of paper, divided into squares, each with a symbol, that can be identified, read and stored by the machine'[6]. These abstractions are the base of a Turing Machine, which was realised in the first 'automatic' computing machines[2] and early digital computers.

Without Turing's work on computable numbers and the identification of the need for finite symbols, numbers such as Pi (π) with infinite decimal places were problematic. A computing machine had to know when to stop and this required computable numbers. Turing devised the logic and maths solutions as abstractions for computing using a single machine, one that could do what it was instructed to do i.e. whatever it was programmed to do. Turing's grid of finite symbols made up of decimal numbers and characters which could be converted to binary digits and vice versa, were the base for machines that could be configured. It was the possibility of multiple configurations that made Turing's digital machine ideas stand out from other machines. Turing's system of binary digits led him to believe also that a universal machine could theoretically imitate any other machine.

Turing's notion of 'symbols in a scanned square, read by a machine' moving from one state to another is echoed in Science Fiction films via visual digital effects of rapid data scanning. For example, *The Terminator* [2] character in the various films of the same name include visual effects of rapid data scanning across a screen, as if from The Terminator's vision. The Terminator appears to process and generate data in a computational read-write process on screen whilst searching for, and matching, data, before executing what it is programmed to do.

Turing envisaged digital machines as universal machines, but it was not until after the war in 1950 that Turing actually articulated 'the three parts of a digital computer: (i) store, (ii) Executive unit (iii) Control' [4] and opened up a much wider discussion on Computing Machinery and Intelligence. Prior to 1950 he was subject to the codes of wartime secrets, yet as he began to articulate a limited base of ideas about the implementation of digital computers, he moved to new abstractions, for intelligent machines. In this discussion he acknowledged various arguments against the possibility of intelligent machinery and simultaneously debunked the myths posed by those arguments. A strong key point of his discussion was on the potential of mimicking discrete state machines, alongside further explanation of binary digits first introduced in his 1936 paper. The detail in Turing's 1936 paper had showed originality of ideas and creativity towards computations for the purpose of realising digital computing machines. Between writing these two papers, Turing had worked at Bletchley Park where he devised methods for searching for patterns in encrypted messages sent via the German Enigma machines.

Turing's digital abstractions were partly realised by others in specific purpose computers, but no one had created a universal machine until Turing. Likewise, few had approached ideas for intelligent machinery as Turing did in 1950. In 1948 Turing had realised a digital computer integrated with electronics, which was also a general-purpose computer i.e. a universal machine. He achieved this whilst working at the National Physics laboratory in the UK, where he built two machines known as the ACE (Automatic Computing Engine), one of which was a pilot. His abstractions and ideas were finally 'put into application… and embodied in electronics" [7] and his many ideas for intelligent machinery, discussed later in this paper have had a profound influence on the computers of today.

3 SEQUENCES, INPUTS, STORAGE, DATA PATTERNS AND SEARCH: THE HIDDEN LAYERS

In the early 1950s Turing worked with emerging computer systems at Manchester University. At this point Turing was setting the standards for early computers on a wide range of matters, from the division of storage for routines and functions to guidelines for electronic tube and magnetic storage, as well as rules for setting up machines i.e. programming them. By 1951 digital machines could send outputs for printing. It was still early days for digital machines, but the integration of electronics was another advance from specific purpose machines of the 1940s. Storage was still very limited by today's standards and Turing could not have imagined early 21st century research on 'dense atom level ferromagnetic storage for data bits' [8], but his work indeed gave rise to the very notion of 'data bits'.

In 1936 Turing articulated the need for a practical split of his abstract binary digits (see introduction) into 5 block sequences of zeros and ones, so that they would be easier to read. In the 21st century humans generally don't read binary data, but this point highlights how close Turing was to the creation of data, ultimately referred to as data bits. The sequences still represent characters, numbers, mathematical formulas and functions, and continue to be the 'hidden layers' between the inputs and outputs of digital machines. Turing's creativity with binary data towards application and his standards for configuring digital machines in universal ways is, as noted earlier, has set the benchmark for computers.

A Turing Machine is any realisation of Turing's abstract machine ideas. The early Turing machines used conventional symbols and characters derived from the typewriter as well as a

[2] The first 'automatic' computing machine in the UK was the ACE computer set up by Turing at the National Physics Laboratory in 1948.

number of Greek symbols used in the convergence process of symbols for sequences of meaningful zeros and ones. In contemporary time the reading, erasing and sorting of symbols, and generation of invisible code is done via a processor and microchips, which are the refinements of Turing's original concepts.

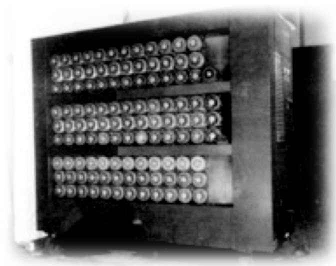
Prior to digital machines, and in Turing's life, office workers who carried out typing and calculations with non-digital machines were actually called 'computers'. Turing envisaged that such human tasks and calculations could be automated, and indeed the digital computer freed up the pool of workers who previously carried out various repetitive tasks.

In hindsight, Turing must have speculated on the design of computer inputs as he reflected on the function of typewriter. By the late 1930s there was no doubt that he saw the keyboard as an input layer for his digital machine, which was not yet realised. To celebrate Turing's observations and the invisible layers that would become part of his digital machines, this paper proposes another abstraction, an Invisible Universal Keyboard (IUK) (see Figure 1). The idea for this keyboard is based on an inverse neural network, which means the inputs are not actually visible, but that there is knowledge of the middle layer i.e. it is made up of binary sequences. Normally, the middle layer in a neural network is hidden and positioned between inputs and outputs. Turing's zeros and ones as a 'middle layer' reinforces the idea that digital machines can be configured with any kind of input and output.

Figure 1: The Invisible Universal Keyboard (IUK) designed by Dowd to highlight Turing's hidden layers of digital computers.

The IUK signifies the reconfigurations of digital computers, first conceived by Turing and transformed with contemporary interpretations from touch screens to electronic brain caps as inputs for digital systems. The blank inputs via the IUK are reminders of the reconfigurations also of digital machines portrayed in Science Fiction films. Here the keyboard quickly fills with symbols for the simulation of human emotions e.g. Replicants programmed with 'emotionally charged memories' [9] triggered via pattern recognition of an image stored in a machines memory, such as in *Blade Runner* [5]. Such configurations are a long way from Turing's work at Bletchley Park, but the principles of configuring digital machines, data storage and the use of search algorithms and pattern recognition are shared features across Turing's ideas and Science Fiction films.

At Bletchley Park in the late 1930s Turing worked with machines that were types of rugged search engines (see Figure 2). These were large machines with cables, jacks, boards and magnetic drums. The latter was part of the search and deciphering process of encoded messages sent by the Germans during World War 2. An important part of Turing's work was searching for patterns in encoded messages, which he and Welchman partly achieved by simulating the wheel settings and board configurations of the Enigma machines used by the Germans. The Bombe and Spider[3] machines together simulated and deciphered many messages from the enigma machines. In addition decoding was informed by identifying 'cribs' i.e. known words that were clues in a message. This helped to identify lexical patterns, but Turing also used mathematical approaches for code breaking.



Source: Bletchleypark.org.uk

Figure 2. A Bombe Machine with magnetic drum storage used at Bletchley Park in 1940 for search and deciphering the messages sent via the Enigma machine.

Turing's work at Bletchley Park ultimately helped turn his abstract ideas into realised digital computers. He knew the limits of stored information on magnetic drums and electronic storage, alongside the rules for setting instructions (programming). In addition he had developed practical skills with sorting, erasing and storing data. He knew the details of search mechanisms and pattern matches developed via code breaking. In contemporary time online searching and matching techniques are obvious extensions of these early concepts, evident in search engines e.g. Google, but the concepts as noted here preceded the Internet.

Turing's approach to search methods and intelligent machinery also included random elements and other ideas that later informed Connectionism, which is 'the science of computing with networks of artificial neurons' [10:402]. The latter can be applied to cognition patterns and for training agents in machine processing, via the associated mathematical patterns of neural networks that can be modelled. The study of neural networks looks at activation across the human brain, body and senses. These levels of research continue to inform Computer science and AI, as well as medical research. Likewise they inform other areas of technology and science, as well as science fiction films and literature.

4 MIMICRY AND EMBODIMENT: SKIN, BRAINS, CONSCIOUSNESS & EMOTIONS

By 1950, once Turing had realised the digital computer, he was aware that computers could mimic almost anything. In particular this would be true if greater storage capacity (memory) was available, and if the process of what was to be mimicked

[3] Turing's notes on the Bombe and Spider are partly explained and edited by Copeland. See [10:313].

was also understood. This was a slight extension of Turing's thinking that digital machines could do many things, by programming it to do different things. His idea of programming other machines was profound because at that time separate machines did different jobs. He articulated his vision for digital computers in the following way:

> [The] special property of digital computers is …that they are universal machines…it is unnecessary to design various new machines to do various computing processes. The can all be done with one digital computer, suitably programmed for each case'. [4:441]

For Turing, greater storage was one of the key factors that would determine the possibility of digital machines going even further and competing with humans. In 1950 he discussed how much storage capacity would be needed for a computer to be successful in his proposed Imitation Game. He started with a calculation for the amount of storage required for an Encyclopedia [4]. For a machine to compete with a human Turing was also keen to understand the human brain and the way in which humans learn. He imagined the structure of the mind and brain in terms of layers and compared the speed of human nerve cells to operations of the machine required to compete in the Imitation Game.

The mind and the brain were not well understood in Turing's time, but he suggested brain mechanisms for understanding how a child might learn, comparing the process to a 'notebook from the stationers…with lots of blank sheets' [4:456]. This was Turing's second reference to paper for recording and storage, and for reading. His first was the digital tape concept as the 'analogue of paper' (see section 2). Paper resonates differently in the 21st century, but Turing's use of paper as an analogy was central to his emerging creativity for envisaging future digital machines, in particular machines that had memory and could mimic other machines.

The potential of mimicry via digital machines raises ideas about machines and embodiment, which is familiar in contemporary Science Fiction films and Robotics. Whilst there are still many gaps between the two, the gap is perhaps closing in some regards, compared to Turing's time. Embodied machines in Turing's life were in the realm of early Science Fiction literature, drama and film, or manifest as integrated hydraulics and springs of the mechanical man, lingering from the mechanical age. Turing's digital technology took the notion of mimicry to a new level, leaving behind the 'impact of automaton technology on 19th century machines [such as that] found in the works of Charles Babbage, the designer of the calculating machines' [11:228]. Turing ideas for future machines focussed on understanding the human brain. His notion of the child's brain being a 'tabula rasa' was just one part of a whole theory that he envisaged for how machines might learn. The metaphor of the blank sheets of the child's brain may be equivalent to storage space on a disk that fills up with the child's experiences like the formation of memory. Turing's discussion about learning machines opened up new intersections across genetics, machines and evolutionary biology. Science Fiction authors extended the mix to genetically engineered machines including generations of machines. These are evident in the literature of Asimov and Dick, in works such as *I, Robot* [12] and *Do Androids Dream of Electric Sheep?* [13], which then turned into the Science Fiction films, *I, Robot* [14] and *Blade Runner* [5].

4.1 Turing on Skin & the Imitation Game: Towards Science Fiction & Inkjet Printers

Although Turing considered that parts of a human being might be imitated, he noted 'there is little point in trying to make a 'thinking machine more human by dressing it up in such artificial flesh' [4:434]. However, that is exactly what Science fiction films do. They create the illusion of artificial flesh regenerated by machine characters, including Cyborgs[4], such as the Terminator character in the film *Terminator 2: Judgement Day* [2]. The mechanical body parts of the Terminator are created by digital compositing (See Figure 3). These are digital applications made possible by the extension of Turing's binary concepts into film editing software, which includes tools for overlaying multiple images.

Source: Terminatorfiles.com

Figure 3. The Terminator character (played by Arnold Schwarzenegger) is a Cyborg with digitally erased skin and composite machine features.

The digital machine as an agent embodied in human flesh was not that important to Turing, but he didn't discard the possibilities of generating artificial substances that would be indistinguishable from human skin. He stated that 'no engineer or chemist claims to be able to produce a material which is indistinguishable from human skin' [4:434]. With his characteristic visionary thinking he added that 'it is possible that at some time this might be done' [4:434]. Indeed, in the 21st century skin tissue is produced using stem cells for regenerative medicine. Stem cells are used to grow skin tissue, which is then printed onto damaged skin via the cartridges of an inkjet printer (see Figure 4). The regeneration of skin using the inkjet process also involves the use of a digital camera and laser, which scans and maps the three main layers of the skin through to the subcutaneous levels of skin, so that the correct stem cell tissue is printed onto the correct area of damaged skin [15].

[4] The word Cyborg was first coined by Clynes and Kline in 1960 and is a portmanteau across cybernetics and organisms. See http://sciencefictionlab.lcc.gatech.edu/SFL/doku.php/cyborgs.

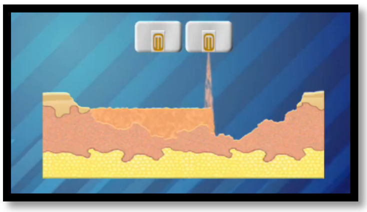


Figure 4. Skin tissue application via an inkjet printer cartridge.

The application of skin using an ink jet printer is not Science Fiction, but may have influenced this combination of digital technology for regenerative medicine. The example shows that Turing's machines continue to grow in surprising ways at the intersections of humans and machines. The inkjet printer application in some ways outsmarts machines of the future that might 'do well' [4:442] in the Imitation Game. The printer in this instance has done better than what humans could do with the application of skin tissues. This suggests some redundancy about the question 'Can machines think?' [4]. Turing's question was perhaps a conjecture, which to echo his own words, are 'of great importance since they suggest useful lines of research' [4:442]. Indeed Turing had started a dialogue about intelligence for future machines, which then spawned new understanding of language, semantics, emotions, artificial dialogue and various intersections between humans and machines.

Turing's ideas for intelligent machinery integrated with the human form, beyond Science Fiction films, raised points of distinction about growing organs from stem cells. His ideas for the Imitation Game were to test 'thinking' based on 'a particular kind of machine…[namely] a 'digital computer' [4:435]. The distinctions are clear in so far as he even restricted the possibility of future individuals derived from biological cell techniques from the Imitation Game, even though he considered that 'rearing a complete individual from a single cell of the skin (say) of a man' [4:436], might one day be possible. His primary point was to envisage future digital machines in the Imitation Game, along the lines of 'imaginable computers that would do well' [4] competing in the game.

4.2 Elements of Machine Consciousness

It appears that conjecture was also at play in Turing's idea for a conscious state of a machine. His ideas on the topic were quite grounded, in spite of the appearance that any idea of consciousness of a machine was absurd. At this level Turing considered the possibility of knowledge depths that might build up within a machine, matched with a machine's programmed capability to reason. His thinking was concerned with logic, rules and accumulated exchanges. It would be a mistake to think that he thought that the sum of these factors was equal to human consciousnesses. He was referring to consciousness in context of 'machines', and this brings his ideas closer to contemporary ideas of machine awareness using sensors and programmed logic to reason about a situation. In several Science Fiction films certain digital looking machines appear to have human desires, if not emotions, such as the NS-5 generation of rogue robots in the film *I, Robot* [14], who set about destroying older robots. Desires and emotions that are integral to normal human consciousness, once merged via fiction into digital machines, gives rise to new interpretations of consciousness. However, even if emotions and desires could be programmed into machines, they would still be artificial emotions and desires. This suggests that future machines, in the extreme situation of coming closer to mimicry of humans, would still have a different kind of consciousness to human consciousness.

A conscious state for a human also includes speech, but the integration of the human voice or speech via a machine alone does not make for consciousness. In Science Fiction films where there is artificial speech and dialogue it can also be as hollow as 'surface acting' [16], and as frustrating to watch as it is to wait on actual voice recognition and speech agents used in contemporary telephony. Even where artificial speech via machines is injected with emotional tone humans know that 'to say "something with feeling" can indeed mean not to feel anything at all' [16], as was observed about the computer HAL9000 in the Science Fiction film *2001: A Space Odyssey* [17]. In the film a certain tone is projected for artificial dialogue via HAL and one could be forgiven for thinking that Dave, a human astronaut in the film, had a similar tone to HAL. Both were somewhat deadpan, but not quite monotone. The dialogue between them introduced a number of tensions about reasoning and emotions, a set of complexities between machine and man certainly not considered by Turing in his discussion on consciousness and the usefulness of artificial dialogue.

Humans in the 21st century have adapted to artificial speech via machines and tend not to respond with great emotion, other than with occasional frustration. Artificial speech combined with artificial emotions can be linked to visual symbols for emotions via digital machines for creative and educational purposes, but clearly this is not the sum of consciousness. The problem of a conscious machine for AI is that it cannot be realised without emotions and 'a sense of selfhood…[as] emotions are intersubjective… emerging from the process of meaningful exchanges between conscious entities that take feelings to be located in understandings of selfhood' [16]. Even where machines are aware of an environment or a situation they don't have that sense of selfhood that is bound to feelings. The appearance of feelings via machines as stereotyped emotions are mapped and programmed actions, according to set conditions.

There is no doubt that Turing knew that a conscious machine was not plausible in the usual sense of the word 'conscious', but he sparked an age old debate as he pursued ideas for 'intelligent machinery'. He was quick to confront his opponents and denounce extreme views such as the 'solipsist[5] point of view that makes communication of ideas difficult' [4:446]. He was determined to keep open the possibility of understanding how 'man thinks…and to include [artificial dialogue] mechanisms in devices…without denying the mystery of consciousness' [4:445-447]. He introduced examples of dialogue that could be used to test someone's actual knowledge of a topic. The text extracts contained known interpretations, beyond the literal text, which he used to demonstrate the issues of how conversation between humans and machines would need to be considered, as they evolved. This was the start for artificial dialogue and speech that has evolved into computer 'chatbots' and voice recognition systems. Turing also signalled early ideas about digital

[5] The solipsist point of view suggests that one can only know one's own mind, not that of another. This view had the potential to block research for finding universal patterns related to mind processes.

machines that executed semantic functions, which provides a link to contemporary Semantic Web contexts. In particular he mentioned 'suitable imperatives expressed within a system…[including] those that regulate the order in which the rules of a logical system concerned are to be applied'. [4:458]. It is via such imperatives and propositions that reasoning via logic begins in the Semantic Web. This is an approach that in recent years has also been taken up by large corporate search engines for search optimisation, such as the semantic search engines used by Google™ and the British Broadcasting Corporation.

Internet connectivity itself is like a distributed brain, and it may be tempting to think that consciousness is lurking amidst such collective intelligence. However, even alongside digital microchips embedded in flesh and a pale mimicry of human consciousness there is very little to suggest that we live in a post-human era. Human consciousness and life remains unique. Nonetheless, the digital age has produced strong Descartes' tones. Turing could barely have imagined his digital concepts reaching outer space let alone digital machine applications working in space.

The first Sputnik satellite was not launched until 1957, three years after Turing's death and human landing on the moon was another 12 years after the first satellites. Science Fiction authors like Arthur C Clarke [18] and Isaac Asimov [12] had ideas for machines in outer space and if still alive they might be surprised by today's lack of 'ability to send one's consciousness to the outer planets and beyond' [19] independent of an actual human body. It appears that human beings and their consciousness are bound to one another, even if undertaking 'Whisky experiments on a Space Station to test the effects of gravity on maturation' [20], for new research carried out in 2012. Turing's digital technology has truly extended to outer space, but his ideas for conscious machines have not yet been realised.

4.3 Sign of the Times: Turing & flowers in the Atomic Age

Turing's depth of enquiry into the physical sciences, and his awareness of nuclear bombs and mass destruction were at a peak in his lifetime. These were the signs of the time that no doubt influenced his thinking. Late in life his intellectual focus shifted from the mimicry of machines towards computational research on chemical changes associated with morphogenesis, and the mathematical patterns in nature such as the Fibonacci numbers in flowers. He carried out much of this work on the first large computer installed in Manchester in 1951, the Manchester Mark 1, where he 'set about using the machine to model biological growth' [10:508]. The early 1950s was also the era in which DNA was discovered and the revelations of life where perhaps more than equal to the parallel destruction of the Atomic Age.

Turing had achieved a new synergy with digital machines and biology models, which opened the way for evolutionary programming concepts for learning machines, produced by random and small shifts in input values across networks of machines. Copeland explains Turing's ideas for networks as 'unorganised machines' [10:403], which Turing first introduced in his 1948 paper *Intelligent Machinery* [21]. In the late 20th Century these ideas inform artificial neural networks for computation and the understanding of brain processes. For example, mapping parts of brain function as mere representations that have connections to certain regions is too simplistic. The connections are somewhat unorganised, which is consistent with connectionist models where 'information is in a constant state of transformation, and therefore it is artificial to separate representations from the processes that transform them' [22:83]. Turing's attention to unorganised systems and patterns in nature for modelling computations continues today.

Since the late 20th century digital machines in Science Fiction films appear to be programmed to recognise and respond to patterns, compete with humans and complete their goals. This core of ideas for digital machines is derived from Turing's work, which since then has grown via 50 years of AI research. Turing could not have imagined that machines of the future, even within Science Fiction films, would grow in so many different ways from his abstractions, applications and imagination. Furthermore, digital computing and AI research has achieved the construction of life-size robots such as the robot Asimo™ [23] built by the Japanese company Honda. Asimo™ recognises patterns, computes sensory data inputs and is programmed to learn. It is a digital machine that responds to humans using pattern and speech recognition and makes matches with stored data, before producing outputs at sensory levels. It records facial gestures via cameras for vision and simulates movements of human limbs. Asimo™ is a complex system built on the core of Turing's digital technology and integrates cameras for intelligent sensing, an idea first mentioned by Turing in 1950, explored in the following section.

5 CAMERAS & MICROPHONES FOR SENSES: MIMICRY IN MACHINES

The imitation of machines using Turing's binary concepts for digital machines had barely begun in Turing's lifetime, but by 1951 Turing seemed confidant that machines could imitate one another if programmed to do so. This is reflected in the following statement:

> The imitation of the machine by a computer requires not only that we should have made the computer, but that we should have programmed it appropriately. [24:483]

In Turing's time there were a limited number of digital computers. It was several years before multiple computers emerged and it was not until the end of the 20th century that computers became consumer commodities. By the start of the 21st century digital programmes and computing devices were pervasive and used for both industry and personal purposes. The film industry up until the 1980s carried out sound and picture editing on machines like the *Moviola* or *Steenbeck,* and by the 1990s editing was mostly done with digital software. Software was also introduced to simulate and manipulate sounds of musical instruments via digital music, which is a story of its own. Digital navigation systems in aeronautics including GPS systems[6] also do more than imitate maps and charts of earlier times. Satellites themselves also depend on digital technology.

Digital technology continues to grow in every field of life, which Turing predicted, even though he would have had no

[6] GPS is the acronym for Global Positioning System, which determines location of a digital device using a system of satellites orbiting the earth. The system allows for real-time communication between mobile devices.

grasp of how widespread his ideas and thinking would become. The realisation of so many machines imitated by digital technology is matched by advances for thinking machines, which Turing first thought might be possible by 'taking a man as a whole and replacing his parts with machinery' [Image 20, Ref 21]. The robot Asimo™, discussed in the previous section, is testament to a stunning start for this idea. Science Fiction films have also created impressions for complex digital machines, including rogue machine that drives dramatic plots and display a gamut of human emotions.

The various man-machine creatures in Science Fiction films also include representations of reconfigured human body parts, illustrated earlier, such as seen in *Terminator 2: Judgement Day* [2] [see section 3]. Typical body parts in Science Fiction films include artificial eyes and robotic arms that help machines to achieve particular goals, some of which conflict with human goals. These traits are in abundance in films such as *Blade Runner* [5], *2001: A space Odyssey* [17] and *I, Robot* [14]. The man-machines in Science Fiction films gather and processes information by artificial vision. Here we see the use of the camera for sensing, represented in what would otherwise be eye sockets of artificial creatures. Such creatures also appear to have sensors to avoid collisions, or smash through walls. A Science Fiction author decides what the fictional man-machine can do and creates the illusion that a creature appears to be programmed, which is realised via digital effects in the film production process.

Actual robots are sophisticated machines and yet quite limited compared to their fictional counterparts. They are programmed for a variety of purposes and achieve many goals dependent on cameras for vision and communication systems, in addition to physics systems for refined action and motion. Turing first saw the possibility of thinking robotic machines in 1950, which included amongst various ideas, observations about cameras and microphones. No one at that point had conceived of the lateral use of media technologies. At this level his continual reflections on the relationship between technology and humans is part explanation towards his ideas for thinking machines, evident in the following:

> A great positive reason for believing in the possibility of making thinking machinery is the fact that it is possible to make machinery imitate any small part of a man. That the microphone does this for the ear, and the television camera for the eye, are commonplaces. One can also produce remote controlled Robots whose limbs balance the body with the aid of servo-mechanisms. [Image 20:Ref 21]

In the 21st century machine vision in robotics extends Turing's ideas for the camera and microphone as prominent features of thinking machinery. In Turing's time such ideas were hardly even found in Science Fiction literature, film or drama. The popular culture of the day still looked to 'mechanical forms'. Turing's ideas for thinking machinery drew on logic, maths, psychology and media, as well as ideas and curiosities about the human brain. Through the combination of his invisible digital abstractions and informed observations, Turing started a new science, which later became known as computer science. His ideas also informed the start of AI research and robotics, which began only a few years after his death. His understanding of the human senses and ideas about what might be possible in the future were explicit and informative for what was to come. The use of cameras for eyes and microphones on a par with the human ear, for listening are still evident in vision and communication systems of intelligent machines, such as the Mars Space Rover (see Figure 5), which uses multiple cameras to guide navigation and for collision avoidance purposes.

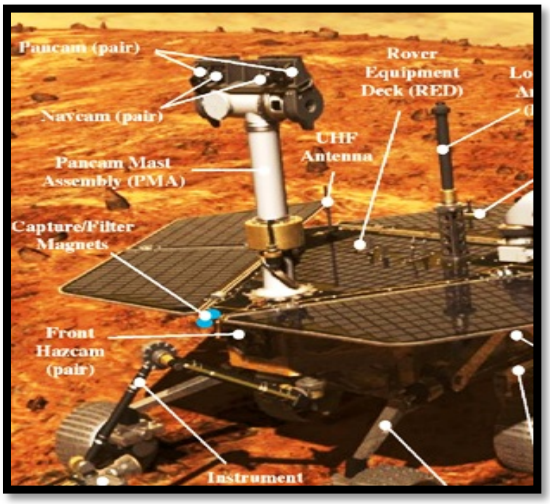


Image source: NASA

Figure 5. The Mars Space Rover uses multiple digital cameras for navigation, panning and detecting hazards.

Intelligent machines are designed to function in particular environments and complete set goals. They have awareness using sensors and cameras, but not consciousness. The processing parts of intelligent machines are often described as the brain. In Science Fiction films robots often display behaviours that are more human-like than a machine. In reality, simulating behaviours involves understanding the connections between the brain of machines and associated actions of multiple human systems, which are complex systems. Understanding brain function and activation of artificial human organs for medical purposes is ongoing research, which continues the mimicry or imitation of machines and humans. But what happens where machines are unstable by design? For example, the machine follows a rule that matches a certain situation, which turns out to be a misreading of the situation because of a lack of data? Turing posed a similar question in 1950 - 'Can a machine be made to be super-critical?' [4:454]. In other words, could humans rely on a machine that has accumulated knowledge, perhaps via networks of machines trained according to certain rules, which are then modified by small shifts in input values, causing them to behave differently over time? The Internet comes to mind alongside Science Fiction literature, film and drama to continue the tease of super-critical machines. The instability of digital code and biological processes is at work in both Science and Science Fiction films.

6. COMPETITION & PROGRAMMED BEHAVIOUR: MOTHERBOARDS AND SCREWDRIVERS

The Voight-Kampff test in the film *Blade Runner* [5] is designed to detect machine creatures that look like humans. The machines are called Replicants and are genetically engineered by the fictional Tyrell Corporation. They are rogue machines. The Voight-Kampff test is used in several scenes in the film, and in the opening scene it is used to check if an employee called Leon is a human or a Replicant. At the mention of the word 'mother' by the interrogator during the test triggers a violent outburst in which Leon suddenly shoots the interrogator. Leon is indeed a Replicant and his actions add dramatic effect to the film. Such actions also open up a discussion about what triggers emotions and the complexity of human systems and process towards *action(s)*, including the challenges of synthetic emotions. In spite of such complexity, research on emotions for machines is ongoing and this paper only highlights some gaps between emotions in Science Fiction films, and it points to the pursuit of emotion connectivity to machines via AI and Computer Science research. In recent years, research on emotions also extends to online technologies, via programming languages to represent emotions. This includes languages such as EARL, the Emotion Annotation Representation Language [25], which is a type of mark-up for emotion representations. We don't know what Turing would make of this research, but we do know that he favoured 'unemotional channels of communication' [4:457] in context of machine learning, to reduce complexity.

When Turing posed the question 'Can Machines think?' [4] he was not seeking a simple yes or no answer via a 'Gallup poll…[indeed not, he even stated]… this is absurd' [4:433]. Rather he was eager to see how humans and machines might compete in the Imitation Game, hence his articulation of 'imaginable computers that would do well' [4] in the game. Competition between man and machines was not new in Turing's time, but by 1950 he was pointing to 'abstract' activities for digital machines, and was not suggesting ideas made earlier in 1948 such as 'taking a man and replacing his parts with machinery' [see section 5].

> We may hope that machines will eventually compete with men in all purely intellectual fields. But which are the best ones start with? Even this is a difficult decision. Many people think that a very abstract activity like playing chess would be best'. [4:456]

Science and Science Fiction films picked up on many of Turing's ideas for building human-like machines, and ran with them. Likewise they took up the notion of competing machines. In 1968 the idea that a machine might be smart enough to calculate and anticipate the next move on a chess board, and win, was depicted in the film *2001:A Space Odyssey* [17]. The victorious computer was HAL 9000. In reality it was 1997 before the first computer beat a human at chess, that computer was known as *Deep Blue*.

By the late 20th century the game of chess was a 'motif' in Science Fiction films from *2001:A Space Odyssey* [17] to *Blade Runner* [5]. In *Blade Runner* the game was a symbol for competition between a machine and a human. The game appears late in the film where the Replicant Roy, played by Rutger Hauer, plays chess with his human creator, the executive genetic engineer of the fictional Tyrell Corporation. Roy is a competing machine to the end and appears to know that he is only programmed to last for a limited time. As Roy's life span looms he tries to hold on to machine life. In Turing terms, Roy may have accumulated memories similar to 'human experiences' but it remains a mystery as to how and why would he be programmed with a desire for life. Roy's expiry date drives the plot and he pursues an extension of his machine life, at any cost. His creator tells him that they can't make changes to his programming as this would lead to deadly permutations. Roy then terminates the executive responsible for genetically engineering him. Roy himself dies in a later scene, holding onto a symbolic dove. In 'genetic algorithm terms' [26] if Roy had artificial genetic inputs they were weighted to fail a 'fitness' test. He also was not 'a learning machine with any particular advantages' [4:456] if thinking in Turing's terms.

In *2001:A Space Odyssey* [17] the computer HAL might have passed a fictional fitness test, had there not been intervention by humans. The astronaut character Dave in the film had no choice but to switch HAL off with a screwdriver after the computer made an error of judgement about communication systems with earth. There is a direct link between this scene in the film and Turing's methods for 'modifying machines, which includes 'paper interference'… and 'screwdriver interference' where parts of the machine are removed' [10:419]. Science Fiction adds emotion at this point. As astronaut Dave dismantles each section of the motherboard HAL protests as if pre-programmed with emotions. HAL was scripted to respond with emotional lines such as "Dave, I'm afraid my mind is going. I can feel it" [17]. In the end, even as Science Fiction machines neither Dave nor Roy was programmed to be 'super-critical'.

Science Fiction drama in Turing's time included robots and rogue machines, but they were not digital in nature. The drama Rossum's Universal Robots [1] (RUR) written in 1920 was popular at that time in both Europe and the USA. In 1938 the BBC also broadcast a live adaptation of the play, which is regarded as the first Science Fiction television show [27]. Whether Turing ever saw the play RUR remains a mystery. He would have been 8 years old when Capek wrote the script for RUR. The play is famous for introducing the word *Robot* into the English language. It has an imaginative plot with manufactured machines that resemble human beings – they are the 'robots' that speak, reason and display emotions, and ultimately plot to get rid of humans. A few years later in 1927 in the film *Metropolis* [28] it is humans who plot a revolution because they have become too much like machines.

In the 21st century Science Fiction drama continues the paradigms of competition and revolution across machines and humans. In reality humans also compete amongst themselves via digital technology, as they are torn between freedom and enslavement. Some people might even rethink notions of machines competing with humans in purely intellectual fields. So, which ones would we stop? This is not a difficult decision. Some people think abstract and arbitrary social activities online would be best.

7 CONCLUSION

Turing's imagination and abstractions are not necessarily easy to see or grasp, but from them has emerged the digital systems that we use everyday. Turing created a base for computers that have been configured, reconfigured and programmed many times, truly satisfying over time a notion of a universal machine. The configurations and reconfigurations continue to satisfy a long list of human traits that draw on ideas of mimicry, towards creativity, healing or destruction.

From digital sequences, inputs, storage and cameras Turing looked to mimicry and simulation, ideas that were evident in Science Fiction stories before and during his life. His observations and articulations about the brain, learning, the body, skin, emotions, evolution, consciousness, media and maths are profound in the trajectory of computing. His ideas and work not only informed the design of digital computers, AI, and morphogenesis, but have influenced many themes in Science Fiction literature and films, including competitions and tests. His ideas have inspired many forms of mimicry, and even parody, all of which contribute to the distinctions to make sure that we know the difference between 'them' and 'us', the machine and the human.

It may be some time before we lose our capacity to make discernments between a human and a machine. Nonetheless IBM has already 'simulated parts of the brains of a cat, a mouse and a rat, towards supercomputer chips, [but] they have only simulated one percent of the human cerebral cortex' [29]. Perhaps in light of this it would be best to conduct Turing's Imitation Game in another hundred years when the brain of the machine will be far more developed. In the interim we can reflect further on mimicry and parody of emerging digital morphing forms. This might include software from the 2012 Designs of the Year Digital Award, via the Design Museum of London [30], which enables face substitution using digital video tools. This software extends the idea of digital compositing of images already used in Science Fiction films, with potential to mimic almost anyone. Such software would allow images of Turing to be layered over an actor's face to recreate a digital version of Turing himself, but we would be no closer to the hidden layers of Alan Turing's mind.

REFERENCES

[1] K, Capek, R.U.R., Rossum's Universal Robots, Prague: Aventinum, 1920.

[2] J. Cameron, (Director). (1991). Terminator 2: Judgement Day [DVD] Tristar Pictures, USA: Carolco Pictures

[3] Lister, M., Dovey, J., Giddings, S., Grant, I., & Kelly, K. (2009). *New Media: A critical introduction*. London: Routledge.

[4] Turing, A.M., 'Computing Machinery and Intelligence' in Mind, Oxford, p, 437. 1950.

[5] M. Deeley, (Producer) & R. Scott. (1991). *Blade Runner:The Directors* Cut [DVD]. USA, Warner Brothers.

[6] A.M. Turing, "On Computable Numbers, with and Application to The Entscheidungsproblem" in Proceedings of the London Mathematical Society, s2- 42 (1): 230-265. 1937.

[7] Hodges, A, Alan Turing — a Cambridge Scientific Mind, [online] http://www.turing.org.uk/publications/cambridge1.html, 2002

[8] BBC "IBM researchers make 12-atom magnetic memory bit" [online] http://www.bbc.co.uk/news/technology-16543497, 2012

[9] H. Heyck, *Embodiment, Emotion, and Moral Experiences: The Human and the Machine in Film*. In: Science Fiction and Computing, Essays on Interlinked Domains, D.L Ferro & E.G Swedin, Eds., McFarland & Company, North Carolina, 2011

[10] J. Copeland, *The Essential Turing*, Oxford University Press, Oxford, 2004.

[11] M. Kang, *Sublime Dreams of Living Machines, The Automaton in the European Imagination*, Harvard University Press, Cambridge,

[12] 2011.I, Asimov, *I, Robot*, New York, Bantam Books, 2008, c1950

[13] P.K. Dick, *Do Androids Dream of Electric Sheep* in Four Novels of the 1960s, Library of America, New York, 2007.

[14] A. Proyas, (Director). (2004). *I, Robot*, [DVD] 20th Century Fox Film Corporation, USA:

[15] US Department of Defence (2009), 'Printing New Skin: Saving Lives with Ink Jet Printers' Video Clip [online] April 3rd 2012

[16] Nofz, M.P. & Vendy, P., "When Computers Say it with Feeling: Communication and Synthetic Emotions in Kubrick's 2001:A Space Odyssey" in Journal of Communication Inquiry, Sage. (2002)

[17] 2001: A Space Odyssey, (Kubrick), Length: 142 minutes, America, MGM, April 1968.

[18] A.C. Clarke, *2001:A Space Odyssey*, Orbit books, 1st Ed. Hutchinson (1968)

[19] P.E. Ceruzzi, *Manned Space Flight and Artificial Intelligence*, in Science Fiction and Computing: Essays on Interlinked Domains, D.L Ferro & E.G Swedin, Eds., McFarland & Company, North Carolina, 2011

[20] BBC News, 'Space station used for Ardbeg distillery experiments' Accessed 10th April, 2012 http://www.bbc.co.uk/news/uk-scotland-glasgow-west-17657804, April 10, 2012.

[21] Turing, A., Intelligent Machinery [online] http://www.turingarchive.org/viewer/?id=127&title=20, 1948M.

[22] Iacoboni, J. Kaplan & S. Wilson, *A neural architecture for imitation and intentional relations*, in Imitation and Social Learning in Robots, Humans and Animals. Eds., C.L. Nehaniv & K. Dautenhahn, Cambridge University Press, Cambridge, 2007

[23] Honda, Asimo Technical Information, [online] Accessed 20th March 2012, http://asimo.honda.com/Abstract-Technical-Information/ 2007

[24] A.M. Turing, "Can Digital Computers Think?" In The Essential Turing ed. Copeland J. (1951)

[25] Schrőder,M., Devillers, L., karpouzis, K., Martin, J.C., Pelachaud, C., Peter, C., etal. What should a Generic Emotion Markup Language Be Able to Represent? (Vol.4738). Berlin:Spinger-Verlag. (2007)

[26] Rowland, Todd and Weisstein, Eric. Genetic Algorithm." From MathWorld - A Wolfram Web Resource. [online] Accessed April 8th, 2012. http://mathworld.wolfram.com/GeneticAlgorithm.html

[27] BBC, "Rossum's Universal Robots", on My Science Fiction Life: The Story of Science Fiction in Britain. [online] 28 Feb 2012 http://www.bbc.co.uk/dna/mysciencefictionlife/A19547274. 2007.

[28] Metropolis, (F. Lang), Length: 153 minutes, Universal Film AG (UFA), 1927

[29] Robertson, J., "IBM Pursues Chips that behave like Brains". 18 August 2011 [online] http://finance.yahoo.com/news/IBM-pursues-chips-that-behave-apf-1651580574.html?x=0&sec=topStories&pos=7&asset=&ccode

[30] Face Substitution, Castro A, & McDonald, K., Length: 1 minute 55 seconds. [online] Accessed May 2012 http://www.designsoftheyear.com/2012/01/31/face-substitution-new-york-usa-arturo-castro-and-kyle-mcdonald/ 2012.