Who was Alan Turing?

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Abstract

When the name "Alan Turing" is mentioned most people think of one or more of the following words: "Turing Machine", "Turing Test", "Enigma" and "Artificial Intelligence". The intention of this article is to present a broader approach to Alan Turing instead of solely focusing on the above mentioned key words. Alan Turing was not only a key figure in computer science and crypto-analysis. His work also revolved around subjects such as the growth of plants, the human mind and he also anticipated many of the issues that are being discussed in today's artificial intelligence research. Being unconventional, ahead of his time as a visionary and openly admitting his homosexuality caused a lot personal problems during his life. However Alan Turing was successfully able to balance his life by relying on personal friends, scientific colleagues, his work and sports. He became a tragic icon when he died at age 42 apparently having committed suicide.

1 Family background and childhood:

Alan Mathison Turing was born in London on 23 June 1912. His parents - Julius Mathison and Ethel Sara Turing - had met in India where Julius worked in the Indian Civil Service. Ethel Sara was the daughter of a chief engineer working for Madras railways. Alan also had an older brother named John. The two boys spent most of their childhood with a variety of foster parents as Julius and Ethel soon moved back to India after Alan's birth. His childhood was mainly influenced by his family situation and his family's upper-middle-class status inside the English society at the beginning of the 20th century. There was little incentive for scientific exploration in the family or school at the time so Alan's first contact with science occurred during his free time. One of the books which he read during his childhood was called *"Natural Wonders Every Child Should Know"*

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2 Alan and the educational system:

Alan's mother was pushing hard for him to adapt to the educational system as she was afraid that his unconventionality would hinder him from educational success. Just like many other gifted people Alan Turing apparently also "found conventional schooling an almost incomprehensible process" [1]. At age 14 he passed his Common Entrance Examination and proceeded to go to Sherborne School. During his first two years at that school he had many difficulties. Alan however won a variety of Mathematics competitions held at Sherborne even though he found it hard to solve examples with the methods taught by his teachers. He spent much of his time reading and trying to understand different scientific works such as the Einstein's "Theory of Relativity" and papers on quantum mechanics.

Things improved considerably in 1928 when Alan met Christopher Morcom. The two boys ended up being very close friends for the next two years and apparently Alan benefited a lot from this close "intellectual companionship"[1] [2] with the one-year older Christopher. They spent a lot of time discussing and working on scientific concepts and ideas. For the first time Alan had found someone who was similar to him. However Morcom suddenly died in February 1930 and it's difficult to determine which effects this experience had on Alan. He certainly started to ponder the question of how the human mind and body were combined and interdependent.

3 Turing the mathematician:

In 1931 Alan Turing started studying mathematics in the renowned King's College in Cambridge. King's College offered a unique atmosphere of intellectual liberty and freedom of thought. Apart from the mathematical and scientific progress that this liberty allowed him it also helped Turing to accept homosexuality as a part of him. Additionally King's College was also more open about politics than most of England. During 1933 Turing was actively participating in the anti-war movement without becoming Marxist or Pacifist like many of his fellow colleagues. He also continued with his sports-activities especially rowing and running.

> "Alan Turing gradually woke up to the fact that by chance he had arrived in a unique environment, which was as much his element as any institution could be."[2] [2]

[1] Hodges, Andrew: The Alan Turing Home Page - Alan Turing: a short biography - 2. 1995. URL: http://www.turing.org.uk/bio/part2.html. Checked on: 31.10.2004

[2] Hodges, Andrew: The Alan Turing Home Page - Alan Turing: the enigma EXTRACT. 1983. URL: http://www.turing.org.uk/book/extracts/ext2-70.html. Checked on: 01.11.2004

During his first years at King's College he recreated several mathematical discoveries by himself. Turing graduated in 1934 and continued to work on a variety of mathematical topics. He wrote a dissertation on probability in which he independently re-discovered a theory which had only recently been discovered by others. At the same time he became increasingly interested in mathematical logic after reading papers by Bertrand Russell and John von Neumann.

In 1935 Turing learnt about a much discussed issue at the time: Decidability ("Entscheidungsproblem"). The main point of the topic was the question whether there was a method which could be applied to any mathematical assumption to check whether it was true or false. Turing was fascinated by this and so he started working on this concept. His work later resulted in the article *"On Computable Numbers, with an application to the Entscheidungsproblem"*. Turing's fundamental idea was that it was possible to create a machine which allowed for basic mathematical operations to be carried out mechanically. In order for the Turing Machine to work the problem had to be presented in a *"definite method"* today referred to as an algorithm. That machine obviously resulted from Turing's extensive thoughts about mind, matter, logic and mathematics. He shared his groundbreaking work with Cambridge Mathematician Newman - who had first introduced him to the topic - in 1936. Unfortunately for Turing the American Alonzo Church had come to a very similar conclusion a few months earlier. Therefore Turing's paper had to be re-written to include references to A. Church and its release was delayed for several months before appearing in the *"Proceedings of the London Mathematical Society"*. The reason why this basic concept of a computer is known as the *"Turing machine"* today is due to the simple fact that Turing had constructed his machine with the real-world in mind while Alonzo Church had a more theoretical approach.

> "..Turing made a bridge between the logical and the physical worlds, thought and action, which crossed conventional boundaries."[3] [2]

During the remaining months of 1936 Turing enhanced his idea by realizing that the best practical approach to the whole issue was a *"Universal Turing Machine"*. The basic idea was that a Turing Machine was only able to solve certain types of mathematical problems as each of them was bound to a certain algorithm. The Universal Turing Machine is able to compute any calculations as long as a standard way of describing the problem is followed. Today an appropriate comparison would be to consider a stored program as a Turing Machine and the computer itself as a Universal Turing

[3]Hodges, Andrew: The Alan Turing Home Page - Alan Turing: a short biography - 3. 1995. URL: http://www.turing.org.uk/bio/part3.html. Checked on: 31.10.2004

Machine. He would have to wait several years before technology allowed for actual machines to be built according to his ideas.

Thanks to the discussions with Alonzo Church, Princeton University accepted Turing as a graduate student in 1936. During this time he closely worked with Church on computational topics while also pursuing a variety of other mathematical areas. He watched the ever increasing threat of Nazi-Germany in Europe and this might have motivated him to work on ciphers and cipher-machines during his time in Princeton.

4 Turing as a code-breaker:

Upon his arrival back to Cambridge in 1938 Turing was approached by the Government Code and Cypher School. In the years leading up to the war the British army was already trying to decipher the Enigma code which the Germans used to encrypt their communication. After war was declared on Germany in September 1939 Turing moved from being a part-time employee to working in the crypto-analyst's headquarters in Bletchley Park. In between 1938 and 1939 little progress was made and only when Polish mathematicians joined the effort in 1939 things started to move into the right direction. The Polish had done a lot of fundamental work as far as coming closer to cracking the Enigma code. They built a machine called a *"Bomba"* based on their fundamental understanding of the Enigma. However it was Turing together with another mathematician called Welchman who first cracked the Enigma code used by the Luftwaffe. This was possible due to Turing's generalization of the Bomba therefore turning it into a more powerful deciphering tool.

While regular deciphering of the Luftwaffe's communication was an important success it was even more important to crack the enhanced Enigma code used by the German Navy for their submarines. Great Britain was heavily dependent on the material supplies from the USA and being able to read the messages sent by the submarines was the edge that the Allies needed to succeed in the long-run. Turing had first cracked the submarine Enigma in 1939. Several improvements in the statistical approach and captured information were required before regular and timely deciphering could take place by the middle of 1941. In February 1942 the Germans suddenly changed the Enigma code so 'Hut 8' where the crypto analysts were working was under a lot of pressure to break the code again. This challenge proved to be a great experience to Turing as it gave him a chance to use the first electronic technology available at the time. He was finally able to work on machines that were closer than ever before to the Universal Turing Machine.

Between November 1942 and March 1943 Turing worked in the USA to discuss code-breaking with other crypto-analysts. He also spent some time on trying to come up with a speech-encryption that could be used

for communication between Great Britain and the United States. In the meantime the crypto analysts at Bletchley Park had regained access to the Navy Enigma. When Turing returned he was assigned to be a consultant on a variety of projects and issues. He spent a lot of time studying and working on the newly built electronic gear that was available in Bletchley Park. During this period he planned to build his Universal Turing Machine by using the digital technology that was rapidly being developed at that time. Turing therefore created the concept of a digital multi-purpose computer. When World War II was coming to its end in 1945 he received the Order of the British Empire for his invaluable contribution as a crypto-analyst.

Even though he was under constant pressure and spent endless hours at his work Turing seems to have enjoyed his time in Bletchley Park. Being amongst like-minded people had always been what Turing wanted and needed in order to feel comfortable. He had also proposed to a female colleague, Joan Clarke, before telling her about his homosexuality and calling it off [3]. This and other incidents proved to be an excellent source of humorous stories which were told all around Bletchley Park. After the war he turned to sports in an attempt to find a balance in his life. Turing had always been ambitious about his goals. It therefore comes as no surprise that he soon became an excellent long-distance runner who could compete with the best athletes at the time. In 1948 he was close to being part of Great Britain's Olympic team if it hadn't been for an injury.

> "I have such a stressful job that the only way I can get it out of my mind is by running hard."[4] [2]

5 Turing the computer and AI pioneer:

Immediately after the war he started working for the National Physical Laboratory (NPL). The goal of the project later named Automatic Computing Engine (ACE) was to rival the American Electronic Discrete Variable Automatic Computer (EDVAC) which was partially planned by Von Neumann. By 1946 Turing had come up with a detailed plan for ACE but it was repeatedly delayed due to a variety of issues. In 1947 he returned to Cambridge after being frustrated by the lack of wartime spirit that had allowed for many important advances. He seemed to take a step back from mathematics, electronics and logic by spending a year studying neurology and physiology. The knowledge obtained during that time was summarized in a paper which was only published after his death. "Intelligent Machinery" was looking at ways to give machines such as computers a mind by adapting nature's concepts

[4]Hodges, Andrew: The Alan Turing Internet Scrapbook - Alan Turing: world class distance runner. 2002. URL: http://www.turing.org.uk/bio/part3.html. Checked on: 1.11.2004

such as neural networks. Turing believed that future computers would be able to achieve everything that human brains were capable of. Today this concept is widely known as "Artificial Intelligence".

In 1948 Turing left the NPL in order to join Manchester University where Von Neumann, who had been the first to read *"On Computable Numbers..."*, had organized for the Manchester Automatic Digital Machine (MADAM) to be built. MADAM was the first working example of the Universal Turing Machine which Alan Turing had planned 12 years earlier. He became the first person to write algorithms and programs for the computer and so some refer to him as being the first programmer. The occasion marked the beginning of the distinction between what is now known as *"hardware"* and *"software"*. There's a debate about whether Turing was successful in working with MADAM. Some claim that his best work during that time was writing the operating manual without actually achieving any significant scientific goals.

It seems certain that Turing was unsure which scientific areas to explore at that time. He re-visited mathematical and philosophical topics that he had previously dealt with. His philosophical thoughts trace back to 1930 when Christopher Morcom died and Alan Turing started to think about topics such as the connection between mind and matter. Many of these early thoughts were recorded in the letters which he sent Morcom's mother. During a vacation in England in 1937 he had met the Austrian-born Ludwig Wittgenstein who many consider to be one of the most important philosophers of the 20th century. Turing's later work and also the discussions he used to have with fellow colleagues show a profound and philosophical understanding of the issues surrounding computers and computational intelligence.

Accordingly his paper called *"Computing Machinery and Intelligence"* was published in a philosophical magazine called "Mind" in 1950. Amongst other things such as a pointing out topics and issues that the AI research is still dealing with today the paper also introduced the *"Turing Test"* which was to become Alan Turing's most famous legacy. The Turing Test consists of a person communicating with a partner via text-messages. The partner can either be another human or a supposedly intelligent machine. In case the person is not able to clearly distinguish between a conversation with the machine and the human then the machine possesses intelligence. Even though the Turing Test is often and heavily criticized it still remains the de-facto standard for testing whether a machine is intelligent or not. This paper was Turing's last big contribution to computer related topics.

He spent the next two years working on several biology-related projects but only one paper was finished while many remained as unfinished drafts. *"The Chemical Basis of Morphogenesis"* dealt with the growth of plants and their physical structure. Turing believed that all living things are shaped due to a series of chemical and physical processes. By trying to find mathe-

matical algorithms that represented this natural shaping he was attempting to solve the issue with the same mathematical approach that had lead to the Turing Machine. Alan Turin strongly believed in a close link between nature and mathematics and he heavily relied on computers to test his mathematical theories and ideas.

6 The last two years:

In 1952 Alan Turing was arrested on the charges of having a homosexual relationship with a young man from Manchester. Practicing homosexuality was against the law and so Turing was put on trial. Given that his only defense was that he did not understand what was wrong with being a homosexual he was convicted. When offered the choice of going to prison or regularly receiving hormone injections in order to treat his homosexuality he chose the latter one. After the trial he lost his security clearance for the Government Communications Headquarters (GCHQ), which was the post-war institution responsible for cryptography, for which Turing had secretly worked. This was the beginning of the Cold War and the widespread McCarthyism dictated that all homosexuals were considered a potential security threat. Alan Turing was very bitter about being excluded and things became even worse when he and his foreign visitors and friends were being observed and investigated.

The public embarrassment combined with the negative side-effects of the injections and the general disappointment seems to have had a devastating effect on Alan Turing. Additionally he was not able to tell his friends about many of the problems he was dealing with because he was not allowed to talk about work related topics. Alan Turing was found dead on 8 June 1954 after eating an apple which contained the poison cyanide. His mother suggested that it was an accident which occurred due to experiments with chemicals. It is however believed that Alan Turing committed suicide.

7 Summary:

In the 42 years of his life Alan Turing fundamentally shaped the world we know today by coming up with a series of unique and outstanding concepts, ideas and thoughts. Amongst other things he was working on fundamental mathematical logic and he created the Turing Machine which served as the theoretical basis for all modern computational machines. During World War II he played a key-role in the cracking of the Enigma code which Nazi-Germany's army used to communicate. This gave the Allied Forces a vital edge especially for transporting materials from the USA to Great Britain. After the war he actively worked on building machines based on his concept of a Universal Turing Machine. Later work resulted in the basis of modern

Artificial Intelligence research with the Turing Test still being a fundamental aspect today.

When Alan Turing was a child his parents had been worried that he would not fit in with the rest of society and they were proven right. Being a mathematical genius and openly admitting his homosexuality often caused him to be an outsider. Both his personality and the scientific mind were strongly influenced during his academic career in King's College. Ultimately Alan Turing seems to have suffered from too much pain mainly caused by post-war society so he committed suicide on 7 June 1954.

References

[1] Connor & Robertson: Alan Mathison Turing. October 2003. URL: http://www-gap.dcs.st-and.ac.uk/∼history/Mathematicians/Turing.html. Checked on: 02.11.2004

[2] Hodges, Andrew: The Alan Turing Home Page. 1995. URL: http://www.turing.org.uk. Checked on: 31.10.2004

[3] Jones, Bonesy: Alan Turing: PopSubCulture.com's The Biography Project. December 2001. URL: http://www.popsubculture.com/pop/bio_project/alan_turing.html. Checked on: 03.11.2004