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History and Legacy of Alan Turing for Computer Science

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Abstract:
Throughout history we encounter some personalities who think ahead of their time and, in many cases, are misunderstood or even wronged. However, they all have one thing in common: they are geniuses who find impressive solutions to complex problems. This article aims to carry out, through bibliographical research using qualitative data analysis methodology, a historical review of one of the important personalities who wrote his name in history and has great relevance in the development of modern computing: Alan Mathison Turing or how it is known: Alan Turing. Considered the father of theoretical computer science and artificial intelligence, he made his great contribution to humanity by developing, in 1936, through an academic article, an automatic machine ("a-machine", which was later called the Turing), who could read and write different numbers and symbols. This article covers since his birth, covering his academic trajectory, understanding a little of his mentality and vision around machines and technological equipment, his partnerships and some interesting facts about his life. Thus, it can be understood that, even at that time, it was already possible to visualize the signs of the first computational logics and realize that machines have dynamics beyond human understanding, as they can also learn from humans and other machines and, best of all, Above all, transmit this knowledge with quality. Thus realizing the legacy and historical milestone that this British mathematician, computer scientist, philosopher and biologist left for the modern and contemporary world in which we live today.

Keywords: Alan Turing, Computer Science, Mathematics, Second World War, Technology.

1. Introduction

Technology is an area that develops and evolves quickly, being in constant transformation. Who would have thought that a computer that, in the 1950s, occupied the space of a room and was structured to perform calculations, would, over the years, become an object of individual use in companies, public institutions and in people's homes? ? Today they are portable and increasingly compact. They were democratized and, today, connected to the internet, they are tools that overcome communication barriers.

In the history of computing it is possible to find important names who contributed to its development and who were often considered “crazy” for thinking ahead of their time. For example, in the 19th century, Charles Babbage and Ada Lovelace were already thinking about technology at a time when this was utopia, 1837. The institutions that could finance their projects simply doubted the usability and ability to transform the reality of the machine they designed. , so they preferred not to give importance to the invention, but the recognition of its genius and usability and viability came later, in 1910.

Thus, a character emerges, already in the 20th century, who also had thoughts ahead of his time, Alan Mathison Turing, considered the “Father of Computing”, had an incredible trajectory of contribution to the science and history of computing technology. This academic work aims to answer the following question:

what is Alan Turing's legacy for the history of computing?
Therefore, this work takes a retrospective look at his life, covering his childhood, academic life and his main contributions during the Second World War that changed contemporary lives.

2. Family And Childhood

Turing was born in Maida Vale, London, on June 23, 1912, where The Colonnade Hotel is currently located. His father, Julius Mathison Turing (1873-1947), worked in the Indian Civil Service (ICS) in Chantrapur, present-day Odisha state, India. His mother, Ethel Sara Turing (1881-1976), belonged to the family of Stoneys who were Anglo-Irish Protestant nobles from County Tipperary and County Longford. He and his older brother, John Dermot Turing, were left with a retired Army couple as their parents traveled between Hastings in the UK and India during their childhood.
He started studying at the age of six at St. Michael's, a school in Charles Road and, from an early age, the teachers and school management recognized his talent. From 1922 to 1926, Turing was educated at Hazelhust Preparatory School in the village of Frant in Sussex. At the age of 13, in 1926, he entered Sherborne School on a boarding basis. This school is in Dorset and, on its first day of school, witnessed the Southampton General Strike. He traveled 97 kilometers by bicycle, alone, to participate, stopping at night at an inn.
At Sherborne, his talent with mathematics and science was not well regarded and valued by some teachers who emphasized a more classical education. But this did not faze Turing, who continued to demonstrate remarkable ability in the studies he loved, even solving advanced problems in 1927, without having studied elementary calculus. At the age of 16, in 1928, he came into contact with the work of Albert Einstein, understanding it, even deducing his questioning of Newton's laws.

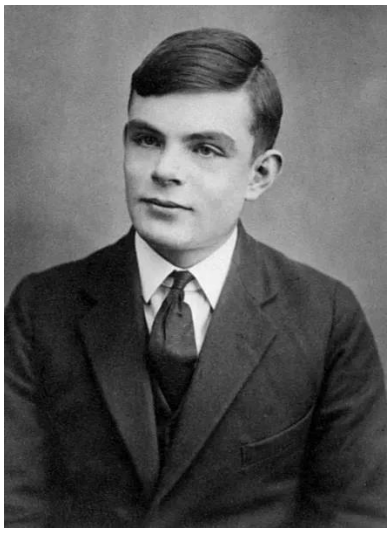

IMAGE 1. PORTRAIT OF ALAN TURING

3. Academic Life

From 1931 to 1934, Turing studied mathematics at King's College, Cambridge, with first class honours. In 1935, at the age of 22, he was elected fellow of the institution for a dissertation that approved the central limit theorem, which had already been proven by Jarl Waldemar Lindeberg. In 1936 he published, in the Proceedings of the London Mathematical Society, the article "On computable numbers, with an application to the Entscheidungsproblem" divided into two parts, the first on November 30th and the second on December 23rd.
Although his theory was published after Alonzo Church's using his lambda calculus, Turing's approach is considered more accessible and intuitive as it included the notion of a "Universal Machine" (now Turing's universal machine). In this idea, such a machine could perform tasks from any other computing machine, such as Church's lambda calculus. By putting them together, they are able to compute anything that is computable. This was recognized by John von Neumann as a central concept of the modern computer, due to Turing's article.
From September 1936 to July 1938, Turing served as a fellow at Princeton University, USA. Studied

cryptology, constituted three of the four stages of an electromechanical binary multiplier. In June 1938, he obtained his PhD from the Princeton Mathematics Department where his thesis, "Systems of Logic Based on Ordinals", introduced the concept of ordinal logic and the notion of relative computation, so that machines were augmented with so-called oracles, allowing the study of problems that could not be solved by machines until then. So John von Neumann tried to hire him as his postdoctoral assistant, but Turing returned to the UK.

Returning to Cambridge, he attended Ludwing Wittgenstein's lectures in 1939, which dealt with the foundations of mathematics. Together with other students, based on their notes, they reconstructed these lectures, even discussing and disagreeing because Turing defended formalism while Wittgenstein proposed his view that mathematics does not discover absolute truths, but invents them.

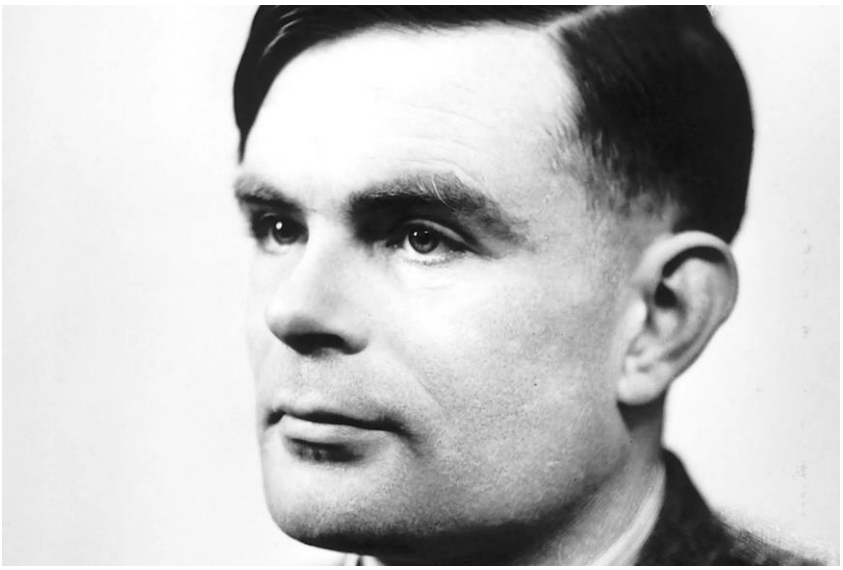

IMAGE 2. PHOTOGRAPHY OF ALAN TURING

4. The Second World War: Career And Research

During the Second World War, from 1939 to 1945, Turing was a leader in breaking German ciphers at Bletchley Park, being recognized by historian and war code breaker, Asa Briggs, who said: "We needed exceptional talent, we needed a genius at Bletchley, and Turing was that genius." But his work dated back to September 1938 when he worked, part-time, at the Government Code and Cipher School (GC&CS), an organization that worked on breaking codes.

Turing focused on cryptographic analysis of the Enigma machine used by Nazi Germany. Together with Dilly Knox, a senior cryptanalyst at the GC&CS, after a meeting in July 1939, near Warsaw, he provided the British and French, through the Polish Cipher Department, with details about the wiring of the Enigma machine's rotors and their method. to decrypt messages. They developed a broader solution. The Polish method relied on an unsafe procedure which the Germans changed in May 1940. Turing's approach was more general, for which he produced a working specification of the electromechanical bomb.

Still in 1939, the day after the United Kingdom declared war on Nazi Germany, on September 4, Turing reported this to Bletchley Park, the GC&CS war station. By using statistical techniques to optimize the judgment of different possibilities in the code-breaking process, he wrote two articles discussing mathematical approaches: "The Applications of Probability to Cryptography" and "Article on Repetition Statistics". These articles were so important to GC&CS that its successor, GCHQ, released it to the UK National Archives in April 2012, just before the centenary of its birth.

In 1946, he was appointed Officer of the Order of the British Empire (OBE) by King George VI for his war services, but his work remained secret for many years as it dealt with war matters.

IMAGE 3. ENIGMA MACHINE ON DISPLAY AT BLETCHLEY PARK IN THE UK

5. The Electromechanical Bombe, Hut 8 And The Naval Enigma

Upon his arrival at Bletchley Park, Turing specified an electromechanical machine called the Bombe that would decipher the Enigma machine, better than the Polish kryptologiczna bomb. Bombe became the main tool for automating attacks on messages encoded by Enigma. It detected a contradiction and discarded it by moving on to the next scenario, with a contradiction occurring when a coded letter is transformed into the same letter in a simple text, which was impossible with Enigma. The first Bombe was installed on March 18, 1940.

In 1941, together with cryptanalysts Gordon Welchman, Hugh Alexander and Stuart Milner-Barry, they created a working system to decrypt Enigma signals, however, due to their limitations, they were unable to translate all the signals. In the summer they were successful in minimizing transport to less than 100 thousand tons of supplies per month, however, despite the investments, they failed.

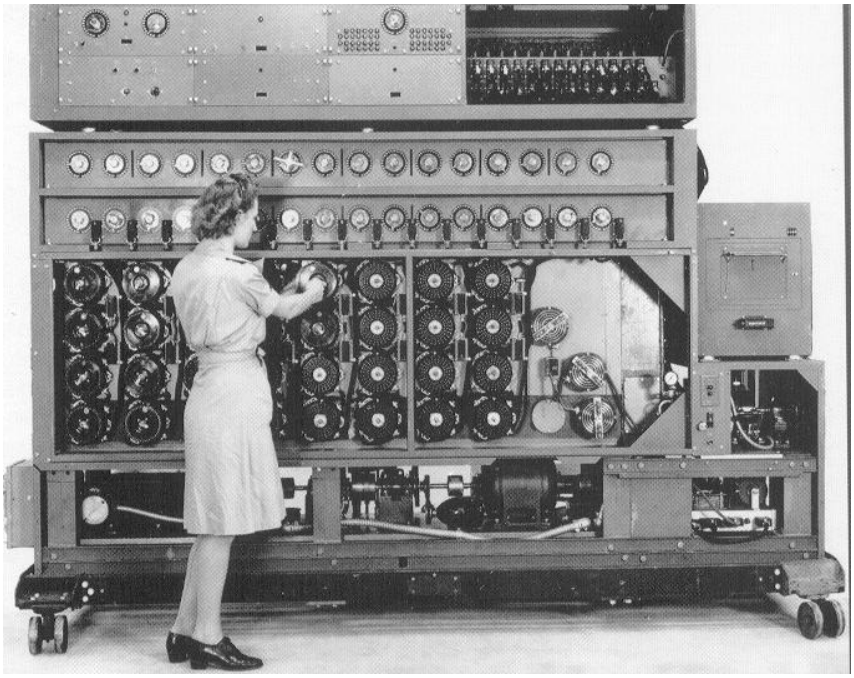

IMAGE 4. THE BOMBE FRONT VIEW

On October 28th they wrote directly to the then Prime Minister, Winston Churchill, demonstrating their difficulties. Thus, they emphasized how little their need was in relation to the investment of men and money that the army made in this time of war, considering the return they would have in the short term. Therefore, on November 18th the head of the secret service reported that all possible measures were being taken and,

by the end of the war, more than two hundred Bombs were in operation.

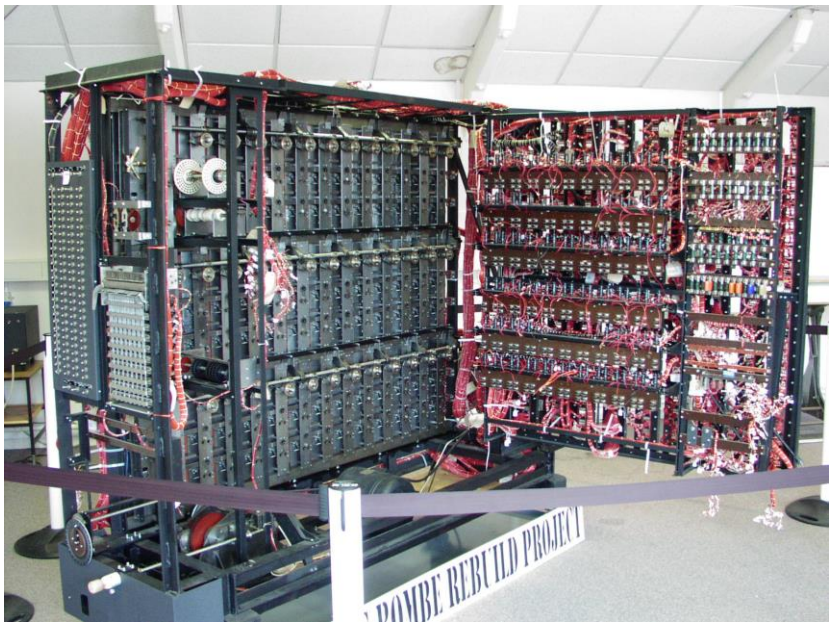

IMAGE 5. REAR VIEW OF THE BOMBE IN BLETCHLEY PARK

Turing also faced the problem of the naval Enigma and, in December 1939, solved an essential part of the naval indicator system, which was more complex than the other systems, in the other services. Thus, he conceived the idea of Banburismus, a sequential statistical technique to assist in breaking naval Enigma codes. Bamburismus discarded certain Enigma rotor sequences, reducing the time to test configurations at Bombes. Later used in the Lorenz cipher.

All this was part of the British service through a code-breaking station, Hut 8, at Bletchley Park, where later, in November 1942, with Turing's trip to the United States, it was led by Hugh Alexander. Later this year, Turing developed a technique called Turingery for use against Lorenz's encrypted messages produced by the new Grheimschreiber machine, the Germans' secret writer.

After his stay in the United States, he adopted the idea of electronic coding of speech in the telephone system, moving to work for the Secret Service Radio Security Service at Hanslope Park, later HMGCC, developing his knowledge of electronics under advisement. by engineer Donald Bayley, where together they designed and built a portable voice communication machine codenamed Delilah.

From 1945 to 1947, Turing lived in Hampton, London, working on the ACE (Automatic Computing Engine) computer project at the National Physical Laboratory (NPL), presenting a paper on 19 February 1946 that was the first detailed design of a computer capable of storing a program. Later, returning to Cambridge at the end of 1947, he produced a seminal work on Intelligent Machines that was not published in his lifetime, however, while he remained in Cambridge, the ACE was being built in his absence. This computer ran its first program on May 10, 1950, and then several computers were produced all over the world. However, the complete version of the ACE was built after his death (June 7, 1954).

6. Personal Life

Alan Turing's private life was tormented by the taboo on homosexuality that existed at that time. In 1941 he proposed marriage to Joan Clarke, a fellow Hut 8 mathematician and cryptanalyst. Their engagement lasted until the moment he admitted his homosexuality to her.

In January 1952, at the age of 39, she began a relationship with Arnold Murray, who was 19 at the time. His home was robbed and Murray reported that he knew the criminal and Turing reported the crime to the police who, during the investigation, recognized a sexual relationship between them. However, at that time, homosexual acts were crimes in the UK, so they went from victims to criminals and were charged with "gross indecency" under Section 11 of the Criminal Law Amendment 1885.

Convinced by his brother and his lawyer to plead guilty, he did so. The case was brought to trial on March 31, 1952 and Turing was convicted. He had to make a sad and painful choice between prison and parole

conditioned on physical hormonal changes designed to reduce libido, also called “chemical castration.” ”. He accepted the option of injections of what was then called diethylstilbestrol (now diethylstilbestrol or DES), a synthetic estrogen. This chemical intervention lasted a year and resulted in impotence and the formation of breast tissue.
As if that wasn't a heavy enough punishment, his conviction also led to the loss of his security clearance, preventing him from serving as a cryptography consultant for the Government Communications Headquarters (GCHQ), as well as from pursuing working in the British signals intelligence agency that had evolved from GC&CS in 1946. He was banned from entering the United States, but had free access to other European countries. Although Turing was not accused of espionage, he was subject to the Official Secrets Act and was compelled not to disclose his work during wartime.

7. Death

Turing was found dead in his bedroom by his housekeeper on June 8, 1954, due to cyanide poisoning. Next to his bed was a partially eaten apple which, although not tested for cyanide, was speculated to be the means by which Turing had consumed a fatal dose of the deadly poison. Even without carrying out an adequate analysis of the death scene, leaving many details to pass without analysis, such as the piece of apple found next to the bed and the existence of a gold electroplating device in the small room that gave off cyanide vapors, the investigation determined that it had been suicide.

According to historians, Alan Turing took pleasure in imagining the scene in which the evil witch in the story of Snow White dipped the apple in the poisonous substance and would have chosen this scene to put an end to his story.

Other historians disbelieve this version because Alan would have faced the chemical castration process with good humor, so he would not have been justified in taking his life. Today we know that people with depression do not always show sadness or apathy, so the fact that he played with the path his life had taken due to the intolerance of the authorities did not mean that he was happy and passively accepting the fate that was imposed on him. What is certain is that whether it was suicide, murder or an accident, we will never know.

His body was cremated at Woking Crematorium on 12 June 1954, his ashes were scattered in the crematorium gardens, following his father's example.

8. Recognition

Turing was appointed Officer of the Order of the British Empire in 1946. He was also elected a Fellow of the Royal Society in 1951. He received several honors, including in Manchester, where he worked at the end of his life. In 1994, part of the A6010 road (belonging to the intermediate ring road of the city of Manchester) was named "Alan Turing Way", also a bridge leading to this road was widened and took the name Alan Turing Bridge.
In 1999, Time magazine named Turing one of the 100 most important people of the 20th century. Also a statue of Turing was unveiled in Manchester on 23 June 2001 in Sackville Park, next to the University of Manchester building, below a plaque reads: "Father of Computer Science, Mathematician, Logician, Wartime Codebreaker, Victim of Prejudice".
In August 2009, British programmer John Graham-Cumming started a petition asking the British government to apologize for the accusation of Turing as a homosexual. The petition received more than 30 thousand signatures. Prime Minister Gordon Brown acknowledged the petition, releasing a statement on 10 September 2009 apologizing and describing Turing's treatment as "appalling".
John Leech, MP for Manchester Withington from 2005 to 2015, authored several bills in Parliament and took the lead in a campaign to secure a pardon for Turing, even though he had committed no crime. Defender of Turing's achievements, Leech maintained in the House of Commons the relevance of Turing's work to victory in the war and this made him a national hero and not a criminal. For Leech, the maintenance of Turing's conviction is, to say the least, vexatious and astonishing. Tireless, Leech continued to support the bill in Parliament and campaigned for its approval for several years until he was successful. Leech's persistence in obtaining a pardon for Turing and, in creating the Alan Turing Act, secured the pardon of 75,000 people convicted under the same law.

On 26 July 2012 a bill was introduced in the House of Lords to grant Turing a statutory pardon for offenses under Section 11 of the Criminal Law Amendment Act 1885, of which he was convicted on 31 March 1952. Later in the year, in a letter to The Daily Telegraph, physicist Stephen Hawking and ten other signatories, including Astronomer Royal Lord Rees, President of the Royal Society Sir Paul Nurse, Lady Trumpington (who worked for Turing during the war) and Lord Sharkey (the sponsor of the bill) asked the then Prime Minister, David Cameron, to act on the pardon request. The government indicated it would support the bill and passed its third reading in the House of Lords in October.

At the bill's second reading in the House of Commons on 29 November 2013, Conservative MP Christopher Chope opposed the bill, delaying its passage. The bill was due to return to the House of Commons on 28 February 2014, but before the bill could be debated the government chose to proceed under the royal prerogative of mercy. On December 24, 2013, Queen Elizabeth II signed a pardon for Turing's conviction for "gross indecency", effective immediately. In announcing the pardon, Chancellor Chris Grayling said Turing deserved to be "remembered and recognized for his fantastic contribution to the war effort" and not for his later criminal conviction. The Queen declared Turing officially pardoned in August 2014. The Queen's action was the fourth royal pardon granted since the conclusion of the Second World War. Pardons are typically granted only when the person is technically innocent and a request has been made by the family or other interested party; none of the conditions were met regarding Turing's conviction.

In a letter to Prime Minister David Cameron, human rights lawyer Peter Tatchell criticized the decision to single out Turing due to his fame and achievements when thousands of others convicted under the same law have not received a pardon. Tatchell also called for a new investigation into Turing's death.

In September 2016 the British government announced its intention to expand this retroactive exoneration to other men convicted of similar crimes of historical indecency, in what was described as the "Alan Turing Law".

In 2014, Turing's biopic was released: "The Imitation Game". Turing was played by British actor Benedict Cumberbatch.

9. Conclusions

Alan Turing was a scientist who thought ahead of his time. His genius was of great use in resolving the Second World War. Thanks to his studies, Nazi Germany was defeated. Furthermore, his best-known invention, the computer, definitely changed the way we live in society. Today we can work anywhere on earth plugged into computer networks thanks to the genius of this man who loved science.

His knowledge may leave a legacy for today. If someone has a computer, or a notebook, or any technology, it is certainly thanks to the “father of computation”.

However, for society at the time, Turing had a major flaw. He was a person who did not fit into the sexual standards considered normal. He was a gay man. The scientific and military circles of the time could not live with a gay scientist, but they could not give up his genius. Therefore, they subjected Alan Turing to chemical castration with injections of stilbestrol, currently known as diethylstilbestrol or DES, an estrogen intended to reduce libido. Faced with such violence, Turing took his own life, ending his brilliant career prematurely.

Alan Turing's story shows us that prejudices are very harmful to society and, in his case, interrupted a successful scientific career with great contributions to the scientific and military world, as well as to society in general. He left this world on June 7, 1954 without having his work widely recognized due to the fact that he was homosexual and due to the secrecy of his war-related research.

Despite all the controversy surrounding his sexuality, his talent and contribution to the modern world we live in today are recognized. If we are in the digital age, then it is because names like Alan Turing helped us have a better quality of life today.

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