# Church-Turing Thesis

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This document gives in the first two chapters a short view into the live of Alan Turing and Alonzo Church. Also the Turing machine is described. Then the separate ideas of Turing and Church are written. They are followed by the description of the Church-Turing thesis.

# Contents

# 1 Alan Turing

On 23 June 1912 Alan Mathison Turing was born in Paddington, London. After his brother John he was the second child of Julius Mathison and Ethel Sara Turing. Very early Turing came interested in Science, so he started making some primitive chemistry experiments. In 1933 he was introduced into the area of mathematical logic. Two years later Turing heard the first time about the Entscheidungsproblem and the questions if it is decidable or not.

He invented 1936 his probably most known work the Turing machine. In this time the possibilities were limited and so the whole work was just theoretic. The functionality of the Turing machine is described in the next section.

After Britain entered war in 1939, Turing started to work full time in the cryptanalytic headquarters. There he help to decrypt the Enigma. 1944 came the first idea of a "computer" into his mind, he spoke about a brain. So nowadays Turing is also known as the founder of modern computer science. Four years later he get offered and accepted a post as Deputy Director of the computing laboratory at Manchester University.

1952 to 1954 he got more and more personal problems and on 8 June 1954 he committed suicide with cyanide poison.[5]

## 1.1 Turing Machine

A Turing Machine is a finite state machine. It consists of an infinite tape, which has at the left side an end and at the right it continued into infinity. At this tape are infinit cells, in every cell is a symbol. This symbol can be 0 or 1. The next part of the machine is a read-write head. There the cells of the tape can be read or written from left or from right.

There are special rules how to respond to the input. These transition rules can be seen as the "program" for the machine. Every of these rules consist out of *current state*, *symbol*, *next state* and *action*. The action is executed if the current state and the read symbol are the same as in the rule. There are three different actions to execute, write, go to the next left cell or go to the next right cell. Also the current state is changed into next State. The machine stops if the current state and the read symbol aren't matching with one of the transition rules or if they are matching with more than one of the rules.[2]

# 2 Alonzo Church

Alonzo Church was born on 14 June 1903 in Washington. With the financial help of his uncle he was able to attend the Ridgefield School in Connecticut. Then he went to Princeton, still in his studies he married 1925 Mary Julia Kuczinski. For about 51 years, till 1976 when Mary died they were inseparable. He had three children with Mary. The first Alonzo Church Jr. was born 1929 in Amsterdam, the second Mary Ann 1933 and the last Mildred in 1938. At the time he developed Church's Thesis he had two small children at home.

In 1927 he visited Harvard for two years and from 1928 till 1929 Göttingen and Amsterdam. After his travels he returned to started his academic career at the Princeton Mathematics Department. In 1967 he left Pinceton and was Professor of Philosophy and Mathematics at the University of California, Los Angeles till 1979 where he was retired from teaching.

On 11 August 1995 Church died in Hudson, Ohio and was buried in the Princeton Cemetery near to his wife.[4]

## 3 The Church-Turing Thesis

It is called *Church-Turing thesis* because Alonzo Church and Alan Turing published about the same time the essential core statement of the thesis. The first one was Church, who published in 1936 something new about recursive functions.[1] His thought was that functions of positive integers are only recursive effectively calculable. Indirect he also got the reverse implication of this thoughts, that every recursive function of positive integers is effectively calculable. Church himself didn't distinguished between this two theses. Generally can be said every function which is effectively calculable also is computable. So they are both known as Church's thesis.[3]

Just some months later Alan Turing published a paper about the Turing machine. A short description can be found in the section about Alan Turing. He proved that the Turing machine can compute every real number, which is computable.[1]

This two theses are very different and at first no one had the idea that they are equivalent. But later it turned out, that if the same set of mathematical functions is chosen, the Turing machine and the thesis of Church are equivalent.[3]

After it was clear, that the are equivalent Stephen Kleene, a student of Church, thought the name *Church's thesis* wasn't suitable any more. So Kleene called it the Church-Turing thesis.[3]

The Church-Turing thesis is not provable, its just a claim. But the claim is plausible on the one hand because of his formal concept and on the other because of intuition. And a third argument for the theses is the fact, that till now no one found a counterexample which would disprove it.[2]

From the beginning on there was a critic voice from Kurt Gödel. Later he was convinced by Turing, but in between he had some critic conversations with Church.[1]

So in computer science usually the thesis is assumed as true. The Church-Turing thesis could be refuted by an algorithm, which is intuitively acceptable and can solve a task, which is not Turing-computable.[2]

## References


[1] Yuri Gurevich Andreas Blass. Algorithms: A quest for absolute definitions. *Bulletin of European Association for Theoretical Computer Science*, pages 2 – 8, 2003.

[2] David Barker-Plummer. Turing machines. In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Summer 2013 edition, 2013.

[3] B. Jack Copeland. The church-turing thesis. In Edward N. Zalta, editor, *The Stanford Encyclopedia of Philosophy*. Fall 2008 edition, 2008.

[4] Herbert B Enderton. Alonzo church: Life and work. In *Introduction to the Collected Works of Alonzo Church*.

[5] Andrew Hodges. Alan turing: a short biography by andrew hodges. http://www.turing.org.uk/bio/, 1998. [Online, accessed 03-June-2013].