

Between punched film and the first computers, the work of Konrad Zuse.

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Pope - Winter 2008.
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The interview for this paper with professor Horst Zuse was possible due the collaboration of Juan Carlos Orozco in Berlin.

Abstract

The Z3 computer made by Konrad Zuse in 1941 in Berlin is described, paying attention in detail to the facts and inspirations related with the use of punched film as a store medium in that machine. The text has several interventions by Horst Zuse, oldest soon of Konrad Zuse.

Introduction

Recently the recognition to the work of Konrad Zuse (1910-1995) is increasing given his achievements as a pioneer of the automatic calculator machines and computers but specially because since the end of the last century, thanks to the work of professor Raúl Rojas, amongst others, it became evident that the Z3 machine, can be considered as the first, electronic (in fact electro mechanical), programable, binary computer in history.

Thanks to a deep study of the patents made by Zuse in the 1930's and 1940's and the creation of simulations Professor Raúl Rojas demonstrated to the computer sciences community that the Z3 is Turing complete. Nowadays even in Wikipedia it is possible to find information about the work of Konrad Zuse and the Z3 computer, it is often present in historical context together with machines as the Harvard Mark 1 and the ENIAC, however there is not much information at available about the particular characteristics of Z3.

Nowadays Professor Raúl Rojas, is the director of a large project called the "Konrad Zuse Internet Archive" were its possible to access the simulations that helped him to understand the Z3 machine, as well as the original Zuse's patents and in general a bast collection of theoretical works about the work by Konrad Zuse from his first machines as the Z1 to his later works.

There are several things that are remarkable about the work of Konrad Zuse,; first of all the fact that his achievements were as far as possible at such time of any kind of military use; secondly the economic conditions and context in which those machines were built. how creative and (hacker) he was in several aspects even in re inventing the Boolean Algebra; thirdly his persistence -most of his machines were destroyed during the WW II-, and finally his double role as a scientist - his work includes the creation of the first programming language, the Plankalküll- and a he was even a painter.



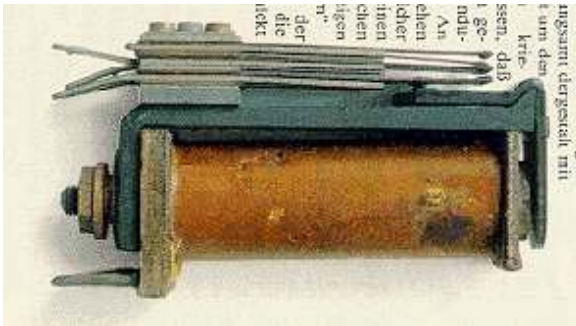
Self portrait by Konrad Zuse. Horst Zuse Web Site.

Besides professor Raúl Rojas others like professor Horst Zuse, Konrad Zuse's first son have contributed to the understanding of Konrad Zuse's work, and in this case the latter will be his voice and will guide us through the work his father. Horst Zuse had a special relationship with his father and he was the eyewitness of that process that so important for all of us today.

Before the Z3

The Z1 was the first machine that Konrad Zuse built, in fact, that machine has the same conceptual architecture than the Z3, the Z1 machine was made between 1936 and 1938 in Berlin and it shows in different ways how Zuse found consistently important and small solutions for the practical problems of creating advanced calculating machines. Both of the machines that Zuse made before the Z3 (1938 - 1941), the Z1 (1936-1938) and the Z2 (1940-1941) were privately financed and were assembled at the beginning in the living room of his parents home in Berlin. (reference to the text by Kittler).

In the Z2 machine Zuse included telephone relays for the first time, despite the fact that Zuse knew at that time about the benefits that working with vacuum tubes can bring, he decided to work with telephone relays because they were more accessible. Even though the work by Zuse was incredibly advanced, only a few people saw the potentiality of such machines.



Original telephone relay for Z1, Z2 and Z3. Horst Zuse Web Site.

To be able to understand the relevance of Zuse's work it is important to bear two things in mind: the first one is that at that time the word "computers" was used to talk about

humans that had the task of doing complex calculations, that means that no machine was considered as a "computer" and the second one is that Zuse didn't have communication with his peers in the United Kingdom or the United States, so far we can deduce that he didn't know the theoretical background of the computational theory of Church and Turing and neither did he know the work of people like John von Neuman at that time, it will happen a long as the time of the WWII.

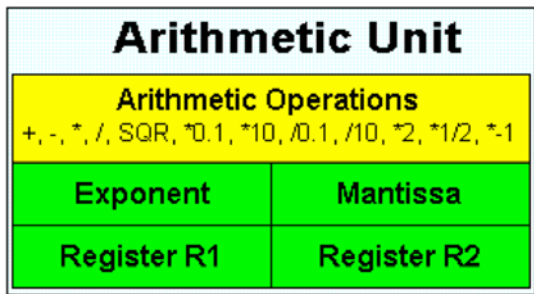
In the words of Horst Zuse:

"This machine [the Z3] is very remarkable and it is accepted today as the first working digital computer world wide, or the first computer with some reductions, because this machine only had an arithmetic unit not a logical unit so it was not possible to compare numbers, it was too complicated at this time to realize it. However it was constructed -how to say- as a minimal system because he was very poor... the financial situation was the following: the Z1 was completely privately financed, it was the Z1 you can see he worked at the living room of his parents and it was financed by his parents, his father - who was a postman- and then his sister -she was a teacher-, some friends from he academic society gave him money and "Kurt Panker ?" who was the owner of a company here in Berlin using simple calculating machines with mechanical basis, table machines, to make simple calculations of additions of numbers but not floating point numbers and so on; and he gave him money, so this machine was financed privately, there was no money from the government for this machine. The same thing happened with the Z2 it was a prototype to try to work with telephone relays, and then the Z3 was financed a little bit by the government they gave him 20.000 "Reich Marks" to built this machine ..."

The Z3

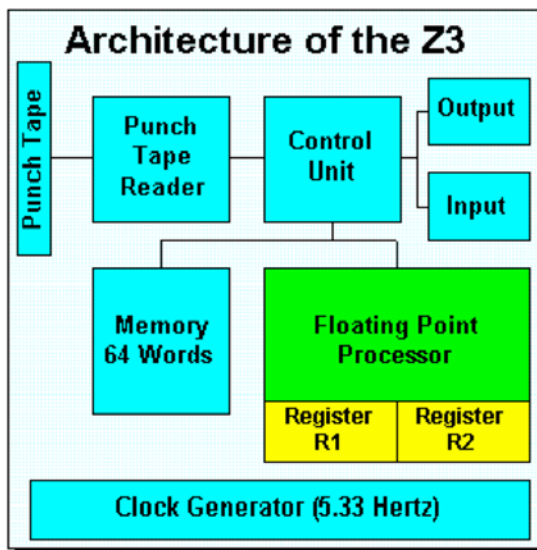
The Z3 was a unique machine and it is in part the focus of this text. To understand the Z3 computer is important to consider that it was made with telephone relays, that means that every telephone relay had to play the role of one bit, because the relays have two states, those states that can be seen as 0 and 1 in a binary system as is the case with the Z3.

In order to understand the principles of this device, we need first to figure out how many relays Z3 had and how they were distributed. The different components of that machine were made with this basic unit: relay (bit). The Z3 had 2000 relays, 700 for the memory, that amount of bits were duplicated because its necessity to store the numbers so in total there were 1400 relays, another 600 relays were used for the processor that include "X" only for the arithmetic unit.



Z3 Arithmetic Unit. Horst Zuse Web Site.

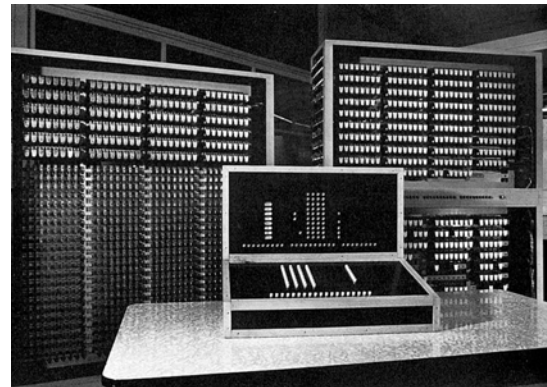
The Z3 had other components as the input keyboard, and the system to display outputs with lamps and the possibility to store and read instructions in punched film, we will talk about that in some detail later on.



Z3 Architecture. Horst Zuse Web Site.

The Z3 computer was able to perform 9 operations, the 4 basic operations which are: addition, subtraction, multiplication and it was also able to calculate the square root. The other four instructions were related with

memory management and input out processes like taking the number from a key board and placing it in the register, display the number in the register, and finally store and load the numbers from the memory. That machine used float point numbers, the numbers were represented with 3 elements, one element to determine the sign of the number, another element for the exponent and a third one for the mantissa.



Z3 in Berlin -. Horst Zuse Web Site.

In the words of professor Horst Zuse:

"It [Z3] was a programmable machine with 9 instructions it has a memory for 64 numbers, or lets say 64 objects, and each object 22 bits it was possible to put in numbers here because were only bits realized with relays, only bits, so you could store letters or numbers or what you wanted, it was a binary memory of this machine, then there was the calculating unit (respect -arithmetic- unit associate today) with the four basic operations in binary floating point number: addition, subtraction multiplication, division and square root; the clock frequency of this machine was 5 hertz and in addition the machine needed 3 cycles that means close to one second, 0. 8 seconds; multiplication about 3 seconds, division the same and square root a little bit longer. And this arithmetic unit made all the basic operations by additions, it means that multiplication was a repeated addition as you do it at home if you are multiplying two numbers and the same for the division, and the square root...."

The launch of the Z3 was not a big success in its time, only five people assisted to the opening and the machine was not operational all the time; however the patents on that

machine, the reconstruction and the following works such as simulations show us that we are looking at one of the first electro-mechanical computers, if not the first one.



Z3 Munchen -reconstruction-. Horst Zuse Web Site.

The punched film use

The use of punched cards is well known as an important component of the computer instructions storage history but the fact that for a long while in Germany some of the computers that Konrad Zuse made used punched film is fairly unknown. This system was designed to record instructions for the computer, for instance the Z3 can work receiving data from the key board, just like a pocket calculator or reading instructions from the punched film, the code to write the instructions is in 8 bits code. Zuse started to use that system because his grandfather used to work in the German film industry UFA.



Konrad Zuse with the punched film in his hands, Z4 machine. Horst Zuse Web Site.

According to Horst Zuse:

"The use of the punched film, as a storage medium, it is not really a storage medium, is not a replacement for the memory, in the memory of this machine there were only numbers, 64 numbers. The punched tape was film it was a 35 mm standard film as it is used by the production companies to make movies, because his grandfather worked with the UFA studios, it was the reason. And it was very good as .. such as "brith ?" 36 mm, and you can make step by step the transport of this punched film, on this punched tape were the instructions of the machine, it was a memory as storage of the instructions, the instructions were not really in the memory of the machine the reason for that is very simple: it was very expensive to do memories at that time, as I said for one bit you need one telephone relay and to buy a relay at that time was 2 Reich Marks and you can see one bit 2 Reich Marks, and soon it was not possible to put in the so called on the memory of this machine, so we have the memory of he instructions on the punched tape and we have some memory for the data in the Z3."



Punched from Z4 machine. Horst Zuse Web Site.

In my opinion the use of punched film was a very interesting decision because at that time the technology to go from one frame to another frame with enough precision was available, they gave the possibility of continuity to the set of instructions, also film is recognized as a stable and non fragile medium, these shows again the creativity of Mr. Zuse.

Finally there is an important functional point that must be addressed here in relation to the punched film system; it is the fact that thanks to the use of film, it was possible to bind it creating loops that would allow the machine to perform recursive operations.

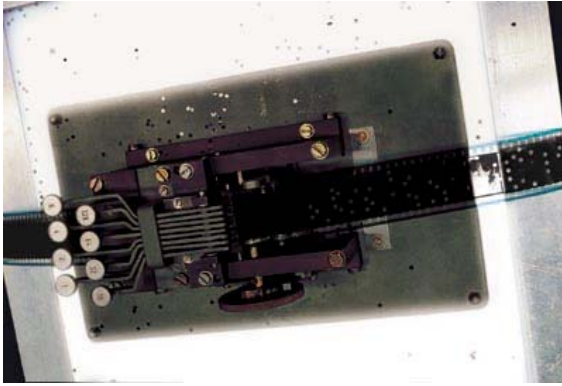
As a person that studied film and that is interested in the work with computers this is more than a simple fact, it is inspirational.



Punched film in loop. Horst Zuse Web Site.

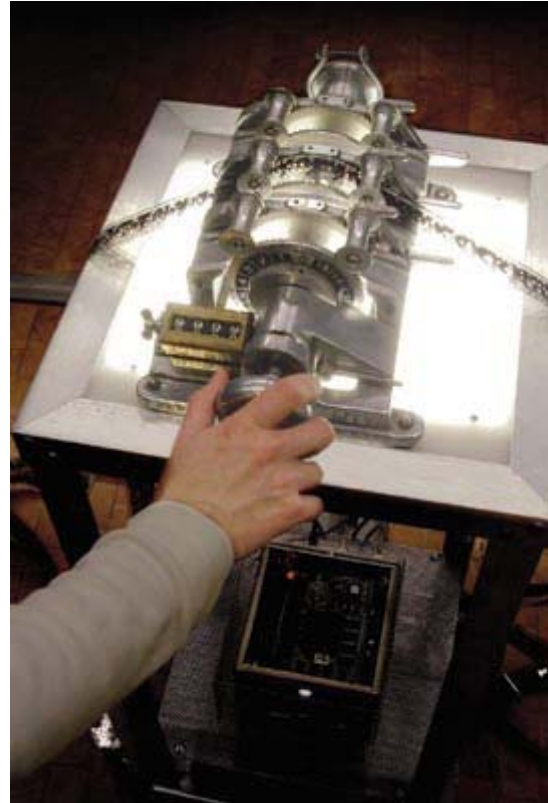
The influence of punched film

Even though the fact that Zuse had used punched film is not well known it doesn't mean that it has been completely ignored; there are very interesting and inspirational examples of reflections about this issue. Probably the most important one is the sentence by Professor Lev Manovich, who teaches at the University of California San Diego, in his text Cinema and Digital Media he said: "Zuse's film with its strange superimposition of the binary over iconic anticipates the process which gets underway half a century later: the convergence of all media, including film, to digital code." According to that it can be said that the history of the digital cinema has its roots in Zuse's work.



Reconstruction of the punch holder used by Zuse. Caspar Stracke Web Site.

In the context of the "Future Cinema" exhibition (2002-2003): "Z2 [zuse strip]" a media art installation that is based specifically in the device to punched the film was exhibited. This installation made by Caspar Stracke receive many interesting critiques and was quite important to show that the device far from being only a rumor was a fact, he used for the installation a replica of the original machine. That exhibition took place in ZKM, Zentrum für Kunst und Medientechnologie and it is significant because later on in 2004 in the context of the exhibition "Algorithmic Revolution" one of the machines made in the 1960's by Konrad Zuse to the ZKM was exhibited, that machine is still there and it is working. The Z22 was the first machine using vacuum tubes that Zuse made.



Reconstruction of the punched film reader used by Zuse. Caspar Stracke Web Site.

In order to close this reflections I want to say that we must bear in mind that the non conventional uses of film technology guides us to interesting moments on the history of media arts, it is important to remember that in the 1930's the film maker Walter Ruttmann made an audio work called weekend "*Wochenende*" using the film camera but with the lens covered with the aim of recording sound only, optical sound. Today "*Wochenende*" is recognized as one of the first radio art pieces in sound art history of XX century.



Installation -Z2 filmstrip- by Caspar Stracke.

Caspar Stracke. Web Site.

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Conclusion

During the course MAT 200C with professor Travis Pope, he insisted many times in the important relationship between multimedia and the evolution of computer hardware specially the storage devices. The Compact Disc that gave origin to the CD ROM, was invented for music purposes, the magnetic tape used in the back up process was invented for sound also and the every day most common DVD drive was invented for video originally.

Bearing in mind that multimedia hardware helps to reconfigure the factuality of computers, well, if we think that in the Z3 the storage medium was punched film, we can affirm that that tendency is not only true today but it was around since the beginning of computers, because film was created to work with images, first in photography and later on in movies.

Acknowledgments

I want to say thanks to Professor Horst Zuse, for accepting to do an interview with us for this project and also for the quality of the information that he shared with us.

Also I want to say thanks to Raúl Rojas, because despite some difficult conditions he found the time to answer my questions.

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Caspar Stracke - [Z2: film strip] Installation web site.
<http://www.videokasbah.net/zuse2.html>