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

Andrés Burbano

PhD candidate in Media Arts and Technology

University of California

Santa Barbara

aburbano@umail.ucsb.edu

Abstract

This paper revisits the work of engineer Konrad Zuse on the basis of an interview with his eldest son, Hörst Zuse. It elaborates on historical, technical and cultural aspects of Konrad Zuse's work, paying special attention to the characteristics of the Z3 computer built in Berlin in 1941. This particular machine is considered today as the first binary, electromechanical, programmable computer. The paper places the Z3 in the context of film historiography and cinematographic alternative developments, taking into account the fact that the Z3 had an interface to read instructions from punched film stock.

Key Words

Konrad Zuse, Hörst Zuse, Z3, punched film stock, early computers, computer history, film history, Walter Ruttmann.

Introduction

Recently the work of Konrad Zuse (1910-1995) has received increasing recognition, in view of his achievements as pioneer of automatic calculator machines and computers; in particular, this recognition is connected to the fact that, since the end of the last century, and thanks to the work of Raúl Rojas and Hörst Zuse amongst others, it became evident that the Z3 machine can be considered the first, electronic or electro mechanical, freely programmable, binary computer in history. Following a thorough study of the patents done by Zuse in the 1930s and 1940s, and through the creation of simulations, Professor Raúl Rojas has demonstrated before the Computer Sciences community that the Z3 is Turing complete.

Nowadays it is possible to find extensive information about the work of Konrad Zuse and the Z3 computer. The Z3 is often presented in the historical context together with machines like the "Harvard Mark I" and the "ENIAC." However there is not much information available about its particular characteristics. One useful source is the "Konrad Zuse Internet Archive," a large project led by Professor Raúl Rojas, where it is possible to access the simulations that helped Rojas to understand the Z3 machine as well as Zuse's original patents, and more generally a large collection of documents by Konrad Zuze about his first machines like the Z1 and leading up to his latest works.

However, much work about the subject is still to be done. There are several things that are remarkable about Konrad Zuse's projects and ideas. First among these is the fact that his achievements had only an indirect relationship with the military context at that time in history. Second, the complex economic conditions under which his machines were built, and Zuse's resourceful creativity in spite of such conditions (he may even be said to have reinvented something similar to propositional calculus, since even Boolean Algebra was little know in Germany at that time). Third, Zuse's persistence (most of his early machines were destroyed during WW II), and finally his double role as a scientist and artist: while his work includes the creation of the first programming language, the *Plankalküll*, he was also an active visual artist for most of his life, and he himself defined his approach to the world as "highly visual".

Besides Professor Rojas, other computer scientists like Professor Hörst Zuse have contributed to the understanding and documentation of Konrad Zuse's work. Hörst Zuse had a special relationship with his father and was an eyewitness of those endeavors so important for us today. That is why later in the paper I will give way to his own voice, to guide us through the work of his father.

Before the Z3

The Z1 was the first computer machine built by Konrad Zuse -- that machine, in fact, had the same conceptual architecture later to be found on the Z3. The Z1 was made between 1936 and 1938 in Berlin and it shows in different ways how Zuse consistently found creative solutions for the practical problems of making advanced calculating machines. Due to its mechanical nature, we can today consider the Z1 as a concrete example of physical computing. (1)

In the Z2 machine Zuse included telephone relays for the first time. Although at the time he was aware of the benefits that working with vacuum tubes could bring, especially because the pioneering work with vacuum tubes by his partner Helmut Schreyer, Zuse decided to work with telephone relays because they were more accessible.

Even though Zuse's work was incredibly advanced, only a few people saw the potential of such machines. 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 denote humans that had the task of doing complex calculations, so that no machine was referred to as a "computer;" the second one is that Zuse had no communication with his peers in the United Kingdom or the United States. So far we can deduce that he did not know the theoretical background of Turing's theory of computation, nor did he know the work of people like John Von Neuman or Howard H. Aiken at that time. He came to know about them only when WWII was over.

In the words of Hörst 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 -who was a teacher-, some friends from the academic society gave him money and Kurt Pannke, who was the owner of a company here in Berlin producing 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 build 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 it is important to consider that it was made with telephone relays and some stepwise relays, meaning that a telephone relay had to play the role of one bit. Since the telephone relays have two states, these states can be seen as 0 and 1 in a binary system, as is the case in the Z3. In order to understand the principles of this device, we need first to figure out how many relays the 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 was duplicated due to the need to store the numbers, so there was a total of 1400 relays, while an additional 600 relays were used for the processor.

The Z3 had other components such as an input keyboard, and a system to display output with lamps, as well as the possibility to read instructions from punched film stock.

The Z3 computer was able to perform 9 operations, the 4 basic operations: addition, subtraction, multiplication and it was also able to calculate the square root. The other four instructions were related with memory management and input/output processes. The machine used floating-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.

In the words of Professor Hörst Zuse:

"It [the Z3] was a programmable machine with 9 instructions. It had a memory for 64 numbers, or lets say 64 objects, and each object 22 bits, it was possible to put in numbers because those 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 for 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 at the time: only five people attended the opening and the machine was not operational all the time; however the patents of that machine, the reconstruction and subsequent works such as contemporary simulations show us that it amounted to the public presentation of one of the first electromechanical computers, if not the first one.

Punched film stock

Film and photography had an important influence on Konrad Zuse's work, as can be seen in several of his early engineering projects: he designed a city inspired by Fritz Lang's film *Metropolis* (also called "Metropolis"); a photo booth system that included a fast development process; and an Elliptical Cinema, with chairs distributed in a elliptical way to grant better access to the screen image. Finally, he chose recycled film stock as a storage medium for his early computers, the Z2, Z3, Z4 and the Z5.

The use of punched cards is well known as an important component of the history of computer instructions storage, but the fact that for a long time some of the computers that Konrad Zuse made employed punched film stock is still fairly unknown. Zuse's system was designed to record instructions that can be read by the computer: the Z3, for instance, can work receiving data from the keyboard, just like a pocket calculator, or reading instructions from the punched film stock. Instructions were written in 8-bit code. Zuse started to use the punched film stock because his grandfather worked in the German film company UFA.

UFA, created during the period of the Weimar Republic, was the most important German film studio -- for a long while it was even an important competitor against Hollywood. UFA introduced developments in most fields of the German film industry, and as the printing industry depends in many important respects on the quality of paper, the film industry is based in many ways on the quality of the film stock itself. At that time the quality of film stock used in Germany was very good and it quickly incorporated changes done in other countries such as the optical sound band. (2)

According to Hörst Zuse:

"The use of the punched tape, as 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 standard 35 mm film like the one used by the production companies to make movies, it was because his grandfather worked with the UFA studios; that was the reason. And it was very good [...] you can make step-by-step transport of this punched tape. 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 = two Reich Marks, and soon it was not possible to put in more on the memory of this machine, so we have the memory of the instructions on the punched tape and we have some memory for the data in the Z3."

Figure 1: Punched film stock from the Z4 computer, (1945). Note the brand name of the film stock (AGFA) in reverse on the right-hand side. (3)

The instructions punched on the recycled film stock were nine: addition, subtraction, multiplication, division, square root, read keyboard, display result, load from memory, store in memory; the instructions were coded/punched with 8-bit format on the film stock. The instructions "read the keyboard" and "display result" would keep the machine from working until the operator had completed the task.

Operation	**Code**	**Kind of operation**

Addition	01100000	(Arithmetic)
Subtraction	01101000	(Arithmetic)
Multiplication	01001000	(Arithmetic)
Division	01010000	(Arithmetic)
Square root	01011000	(Arithmetic)
Read keyboard	01110000	(Input/Output)
Display result	01111000	(Input/Output)
Load address z	11 z6, z5, z4, z3, z2, z1	(Memory)
Store address z	10 z6, z5, z4, z3, z2, z1	(Memory)

The holes were punched using two different rows because apparently the film was not long enough to write 8 holes in a single row. Filled spaces and punched holes work as zeros and ones. A similar system was preserved at least until the time of the Z5.

The fact that Zuse used recycled film stock is another proof of his inventiveness: Zuse can be said to have brilliantly introduced, to some degree, the idea of sustainable computing, since he was using materials that were discarded by another industry; on the other hand, it is an example of how economic were the solutions that Zuse was able to find. Ultimately, it was those economic decisions that would make possible to make the Z3 working and operational.

Additionally, the use of punched film stock was a wise decision because at that time the technology to go from one frame to another frame with sufficient precision was available in the context of the film industry. For Zuse's purposes, this allowed for the possibility of precise continuity from one set of instructions to another one, a feature that is undoubtedly crucial for his system.

We must have in mind that in its original conception the Z3 was designed to use punched paper tape of the kind that had been used for a while in Teletype machines and that would later on be used in several computers. According to Zuse, the idea of using punched film stock came from Helmut Schreyer. An important functional advantage gained from the use of film stock was the possibility of binding the stock in order to create "loops" that would allow the machine to read instructions in a recursive way. Fact that is evident in some of the pictures of the Z4 computer that still remain today and that would not have been possible using punched paper tape.

Figure 2: Punched film stock in "loop" Z4 computer (1948).

Copyright: Hörst Zuse.

Some reflections about the use of punched film stock and a moment for imagination

These facts open our eyes and allow us to think about film not only as an art or industry, but also as a technology. In Zuse's day, all the mechanisms employed to advance the film stock were precise, and film stock itself as technological solution was uniform enough, flexible and stable, which made it possible to use it in different ways and forms. As a matter of fact, unconventional uses and manipulation of film and film stock would open the doors to innovative cultural practices, in this particular case: storing code.

The fact the film stock used for storing the code was already exposed yields one of the most enigmatic moments in the story I have been tracing: the beauty of the fragments of code punched over cinematographic scenes in the background. Now I am going to take the risk to propose an image: imagine some frames of the film *Metropolis* in the background of the punched film stock, now go on a bit further and imagine frames of particular moments of the film, when men are seen interacting with some machines that resemble computers, with screen-like numerical displays, video conference interfaces, input devices and rolled paper tape output. This is the image that I want to propose as a manifesto.

Figure 3: Frames from Metropolis (Fritz Lang, 1927) in the background of film stock punched by Konrad Zuse (1941). Collage by the author.

Copyright of Konrad Zuse's punched film stock picture: Hörst Zuse.

Copyright of Metropolis: Public Domain.

The technology of film allowed Fritz Lang to engage in a complex process of imagination and anticipation of the future, and to represent a futuristic landscape with machines dramatically close to computers (we should not forget that computers were invented a couple of decades after *Metropolis*), but it was also capable, as a technological solution, to function as support for the coded instructions of one of the first freely programmable computers in history. This, in my opinion, only begins to raise a set of questions about what film and cinema are, and shows how far we still are from a complete understanding of what cinema implied in the history of the XX century.

Figure 4: Fiction: Metropolis (Fritz Lang, 1927). Reality: Konrad Zuse with punched film stock in his hands, Z4 computer (1948).

Copyright of Konrad Zuse's picture: Hörst Zuse.

Copyright of Metropolis: Public Domain.

Another example of non-conventional uses of film technology

In order to open a bit more this line of thought regarding the versatility of film and its double status as technology and as a powerful tool of representation, creation and imagination (and the fact that both can sometimes point in the same direction), it is useful to consider another unconventional use of film technology that would lead to a new experience in the history of culture: radio art.

In 1930 the filmmaker Walter Ruttmann (1887-1941) made in Berlin an experimental film documentary entitled *Weekend* ("Wochenende"). The film was an uncommon one, so uncommon in fact that it had no images: it consisted only of audio extracted from sound recordings of a weekend in Berlin, from Saturday to Monday morning (the project was originally commissioned by Berlin Radio Hour in 1928).

At that time Ruttmann was well known for his documentary *Berlin Symphony of a Great City* and his avant-garde animated films -- movies like *Light-Game: Opus I*, full of new drawing techniques and edited according to musical and rhythmic principles.

The recording of sounds for the acoustical film *Wochenende* was possible thanks to recent developments in the technology of film: sounds were recorded -- probably the right word is *filmed* -- on optical sound film implementing the new Tri-Ergon process that used 42mm film. Walter Ruttmann filmed his documentary with a movie camera, covering the lens in order to only shoot the sound; it was recorded using an optical sound system of density variation. Despite the fact that Fritz Pfleumer had invented audio magnetic tape recording in 1928, it would not be until later that reliable portable recording equipment was available.

Today *Wochenende* is considered one of the pioneering, if not the very first work of "radio art," clearly anticipating several important features of *musique concrète*.

To add some more information on this topic, and to show to what degree the German cultural scene at that time was alert to the alternative use of film and film stock, I would like to mention the fact that Bertolt Brecht (1898 -1956) used film stock to create big albums of his theatrical plays.

Brecht, that is, would document rehearsals of his plays, and would later use the film stock to compile books, resembling storyboards, gluing the different strips to create pages of 16mm film stock and finally large albums. These *Modellbuch* (Book Models) played an important role in his methodological approach to performance. (4)

Punched code on film stock, sound recorded with a cinematographic camera, and books made of film stock are just some of the examples I have been able to find of the non-conventional use of film technology and its impact in different levels of culture in the 1930s and 1940s. Why all these processes were happening more or less at the same time in Germany is a question that will remain open for the experts on cultural studies and writers on technology and society.

Back to punched film stock

Although the fact that Zuse used punched film in his computing machines is not well known, it has note gone completely unnoticed: there are indeed a few interesting and inspirational instances of reflection on the topic. The most influential among these is most likely the statement by UCSD Professor Lev Manovich, who claimed in his text "Cinema and Digital Media": "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." Following the implications of this statement it could be argued that the history of the digital cinema has its roots in Zuse's work.

In the media arts context, the exhibition *Future Cinema* (2002) included an interactive installation by Caspar Stracke ("Z2 [zuse strip]") based on the recreation-reconstruction of the device used by Zuse to punch the film stock in the 1940s. (5)

The installation operates as a window to other instances of reflection about Zuse's work and its cultural implications. It includes two quotations, one is another text by Lev Manovich (with a reference to punched film stock) and the second one is an excerpt from the book "The Decipherment of Linear B" by John Chadwick. Chadwick had played a central role in the decipherment of a proto alphabetical script from ca. 13th century B.C. in Greece known as “Linear B”. (6)

The installation recalls to our attention the meaning of the archeology of a technological artifact and also the cultural complexity of code-breaking and script decipherment practices.

Before concluding

It is possible to further explore the richness of Konrad Zuse’s work, his computers and other machines and their relationship to the visual arts, by taking a different, potentially less hazy path.

In 1961 Zuse built the Graphomat Z64: a high precision drawing machine, in fact one of the first digital plotters worldwide. This device had an important and direct impact on the arts of the XXth century.

Georg Nées - regarded today as the first artist ever to have presented a solo show of digital art - and Frieder Nake were two of the European artists who pioneered the implementation of software to create visual artworks, coming up in the process with the concepts of randomness and control, information aesthetics and algorithmic visual composition.

Nées and Nake, some of their works are considered foundational in the history of digital art, had in fact used the Graphomat Z64 to produced their first pieces. In those pieces the creation process is a negotiation between the author’s idea, formulated as a set of rules (algorithms), and the performance of the machine that interprets and executes that set of software instructions. This has deep implications if we bear in mind that at the time of their composition in the late 1960s the idea of authorship had come to be seriously questioned in the theory of the arts.

What is here relevant is that it is not by mere coincidence that Nées and Nake would end up using a machine designed by Zuse. Konrad Zuse was an inventor deeply interested in the visual arts: he thought about practical ways to link them through the creation of machines, but he also took time to write about it. We have proof of this two texts written by him in the 1960s about the possible use of the computer by an artist and its implications for the graphic and applied arts:

- "Über den Einsatz von programmgesteuerten Rechenmaschinen auf dem Gebiete der Graphik und des Kunstgewerbes [On the use of program-controlled calculating machine in the domain of graphics and the applied arts]" (1964).

- "Der Computer als Hilfsmittel des Künstlers [The computer as a tool for the artist]". (1969).

Conclusion

UCSB Professor Travis Pope has insisted on the important relationship between multimedia devices and the evolution of computer hardware and storage devices in particular. This implies that multimedia computers are not, as is often thought, the product of a late process of development -- far from this, the relationship seems to be a constant: the Compact Disc that gave origin to the CD ROM was invented for music-related purposes, the magnetic tape used in the back-up process was also invented for sound recording, while the common DVD drive was originally invented for video.

Thus, if it is the case that multimedia hardware is such an important factor in reconfiguring to such a degree the factuality of computers, the use of punched film stock as storage medium in the Z3 demonstrates that this tendency is not only true today, but was already around since the beginning of computers, given that film stock was created to record images, first in photography and later on in movies.

Additionally, and from a broader perspective, I would like to urge a deeper inquiry into constellation of problems exposed on this paper. A tentative title for such a line of inquiry might well be: *From Caligary to Zuse*.

Notes

1. Both of the machines that Zuse made before the Z3 (1938 – 1941) namely the Z1 (1936-1938) and the Z2 (1940) were privately financed and were originally assembled in the living room of his parent's apartment in Berlin. This fact first came to my attention in reading Professor Friedrich Kittler's book *Gramophone, Film, Typewriter* -- at that moment I was surprised but I must confess I was skeptical about it.

2. The precise mechanics involved in advancing film stock frame-by-frame was already fundamental to all processes of cinematographic production by that time: shooting, mixing, editing and projecting.

3. Rechenprogramm Im Zuse Rechenautomaten

Durch die vorigen Rechenschritte stehen

in Rechenwerk
die Zahl a
in den Speichern Nr. 2 6 10
die Zahlen b c d

e= - a * d + d /c

Speicher Nr. 10
(e ersetzt dort d)

Abrufen Speicher Nr. 2
Multiplizieren
Abrufen Speicher Nr. 10

Addieren

Abrufen Speicher Nr. 6

Dividieren

Vorzeichenumkehr

Speichern auf Nr. 10

4. Images of these astonishing "book models" were published by Hubertus von Amelunxen in the catalog of the exhibition *Notation* 2008, detailing Brecht's systematic use of such books (one example is the album for the play "Man Equals Man," composed in 1931 with following that method).

5. *Future Cinema* (2002) took place in ZKM (Zentrum für Kunst und Medientechnologie), a significant fact given that later on, in the context of the exhibition *Algorithmic Revolution* (2004), the ZKM also exhibited one of the machines made in the 1960s by Konrad Zuse, a machine (the Z22) that is in fact still still operational. The Z22 was the first machine using vacuum tubes that Zuse made.

6. The two texts quoted by Caspar Stracke are:

"If the history of analog cinema officially begins in 1895 with the Lumières, the history of digital cinema, which yet is to be written, can start in the late 1930s with German Zuse. Starting in 1936, and continuing into the Second World War, German engineer Konrad Zuse had been building a computer in the living room of his parents' apartment in Berlin. Zuse's machine was the first working digital computer. One of his innovations was program control by punched tape. For the tape Zuse used discarded 35mm movie film. [...] Whatever meaning and emotion contained in this movie scene are wiped out by this new function as data carrier. "Cinema by Numbers" by Lev Manovich.

"The urge to discover secrets is deeply ingrained in human nature; even the least curious mind is roused by the promise of sharing knowledge withheld from others. Some are fortunate enough to find a job which consists in the solution of mysteries [...] There are obvious resemblances between an unreadable script and a secret code. Similar methods can be employed to break both. But the differences must not be overlooked. The code is deliberately designed to baffle the investigator. The script is only puzzling by accident." "The Decipherment of Linear B" by John Chadwick.

References

Bauer, Friedrich, 2002, The Plankalkül of Konrad Zuse - Revisited. In: Rojas, Raúl, and Hashagen, Ulf, eds. 2002, The First Computers History and Architectures. Cambridge, Mass: MIT Press, 277-293.

Burbano, Andrés and Orozco, Juan (2008) Interview with Hörst Zuse. Interview made especially for this paper. Berlin. Unpublished.

Chadwick, John (1958) The Decipherment of Linear B. Cambridge: Cambridge University Press, 1-40.

Gunning, Tom (2006) The Films of Fritz Lang. London: British Film Institute.

Hertz, Paul (2009) “Art, Code and the Engine of Change”. Art journal. College Art Association. Spring 2009.

Kittler, Friedrich (1999) Gramophone, Film, Typewriter. Standford: Stanford University Press.

Manovich, Lev (1995) Cinema and Digital Media. In: Shaw, Jeffrey and Schwarz, Hans, eds, (1996) Media Art Perspectives. Ostfildern: Cantz.

Nake, Frieder (2009) “The Semiotic Engine: Notes on the History of Algorithmic Images in Europe”. Art journal. College Art Association. Spring 2009.

Rojas, Raúl, 2002, The Architecture of Konrad Zuse’s Early Computing Machines. In: Rojas, Raúl, and Hashagen, Ulf, eds. 2002, The First Computers History and Architectures. Cambridge, Mass: MIT Press, 237-261.

Speiser, Ambros, 2002, Konrad Zuse's Z4: Architecture, Programming, and Modifications at the ETH Zurich. In: Rojas, Raúl, and Hashagen, Ulf, eds. 2002, The First Computers History and Architectures. Cambridge, Mass: MIT Press, 263-275.

Von Amelunxen, Hubertus, Applet, Dieter, Weibel, Peter, Lammert, Angela, eds (2008). Notation. Kalkül und Form in den Künsten. Berlin: Akademie Der Künste and ZKM, 395.

Youngblood, Gene, (1970). Expanded Cinema. New York: E D Dutton & Co, Inc.

Zuse, Konrad (1993). The Computer My Life. Berlin: Springer-Verlag.

On line References

Föllmer, Golo (2004). Ruttmann, Walter: Weekend. Media Art Net [On line]. Karlsruhe. Retrieved from: http://mediaartnet.org/works/weekend [Accessed 14 September 2010]

Manovich, Lev (1999). Cinema by Numbers: ASCII Films by Vuk Cosic. CONTEMPORARY ASCII [On line]. Retrieved from: http://www.ljudmila.org/~vuk/ascii/lev_eng.htm [Accessed 14 September 2010]

Rojas, Raúl, Zuse, Hörst et al (1999). Konrad Zuse Internet Archive [On line]. Berlin. Retrieved from: http://www.zib.de/zuse/ [Accessed 14 September 2010]

Stracke, Caspar (2002). Z2 [zuse strip] - interactive installation [On line]. New York. Retrieved from: http://www.videokasbah.net/zuse2.html [Accessed 14 September 2010]

Acknowledgments

I would like to thank to Professor Hörst Zuse, for accepting to be interviewed for this project and also for the quality of the information that he shared.

The interview for this paper with Professor Hörst Zuse was possible thanks to the collaboration of Juan Carlos Orozco and Lucia Ayala in Berlin.

Biography

Andres Burbano is currently a PhD candidate of Media Arts and Technology at University of California Santa Barbara.

“Burbano, originally from Colombia, explores the interactions of science, art and technology in various capacities: as a researcher, as an individual artist and in collaborations with other artists and designers. Burbano's work ranges from documentary video (in both science and art), sound and telecommunication art to the exploration of algorithmic cinematic narratives. The broad spectrum of his work illustrates the importance- indeed, the prevalence- of interdisciplinary collaborative work in the field of digital art.”