

TURING a staged case history

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Abstract. **TURING a staged case history** [1] brings to the stage the thought and work of Alan Turing (1912-1954), English mathematician and logician, cryptanalyst, considered one of the fathers of the computer science. The scientific papers of Turing, its algorithms, the documents of the period, produce a stream of processed data put on the scene in real-time. Thanks to specially developed softwares, music and image become languages of the dramaturgical process that lead the multimedia show. Live electronics and live video interact with the word and the body of the actor – Turing was also an excellent runner – in a constant interaction of computing processes of the human and the electronic brain.

1 INTRODUCTION

*“Mathematical reasoning may be regarded rather schematically as the exercise of a combination of two facilities, which we may call intuition and ingenuity”*²

In 1936 was published “On Computable Numbers”, by the mathematician and genius Alan Turing. He established the logical fundamentals of our contemporary digital universe.

This makes a compelling reason to start a work around his figure: mathematician, philosopher, computational biologist - visionary architect who anticipated the today’s digital world and the AI concept - initiator of early electronic computer projects, code-breaker for British intelligence during WWII, and a marathon runner of near Olympic standard.

His life so full as to seem like fiction - with all its theatrical features and myths, and ending with a tragic death, a perfect example of Turing’s undecidability - this was a revelation.

The reading of Turing’s intense biography written by Andrew Hodges [2] shows his complex life and humanity.

The researches for the project embarked through travels, looking for Turing documents and places, especially to Bletchley Park, meeting scientists and technology experts, historians, writers, intelligence agents, veteran witnesses of the WWII.

Documents and information collected have impelled us to elaborate an artistic work focused on Turing’s ideas, life, projects, and to take it on stage with a play made of actions, sounds, words, images, videos and real time data, all controlled by live performers. The actors use machines with software programs developed according to Turing’s writings - respecting his essential and extraordinary ability to realize, and make the inventive complexity of his vision and logical thought accessible via his unique creativity.

The play, divided into scenes, which form a machine source code to the entire work, that can modify itself helped by the

presence of the actor, performers and mediated by the concept of time: sudden accelerations, rhythms and speed metaphorically communicate the brevity of his life, the historical context and the new digital time introduced by his researches. The aim is a collating of the fragments of history into a greater decoded universal meaning - a real counterpart to Turing’s universal machine - as embodied in the life and work of Alan Turing himself.

Artists and technology experts are called on for musical compositions and for live execution of music and visuals, orchestrated data, logical concepts, and mathematical algorithms - and where feel necessary, describing living emotions, with sounds and images designed to evoke the flow of breath; sensorial data entwined with memory are represented by sound and video, and powerful sensation arises as from within. We perceive the theatre environment as an extension of the inner space of the actor, his body- machine delivering emotional variables – breaths, pauses, heart beats, movements – constantly monitored by sensors and re-elaborated and amplified to the audience.

The representation of connections within the brain, a drive to imitate a human brain and its structures, forms the thread of the action. A pervasive feature of Turing’s work, was his extraordinarily ability to simplify our world of complexity by his visionary insight into its secret structures.

2 THE PLAY

Ten scenes with a prologue and an epilogue constitute the structure of the entire play.

2.1 Prologue



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² A. Turing, *Systems of logic based on ordinals*, Princeton PhD Thesis, 1938

In the prologue the scenic environment, in which the multimedia action will be developed, is showcased to the audience. A performer ensemble take place to their own console, and play a computer generated music score interacting in real time with the actors.

Actor's heartbeat and breathing dictate the rhythm of the show. The stage space becomes an extension of the interior space of the actor and Turing himself.

Kronos, the time that accompanies Turing, ahead of his times, in the scan of his time, is presented.

2.2 Scene I - 1926 Sherborne



Dear Mother & Daddy, On ship found that all railway services were cancelled... so I cycled as programme left luggage with baggage master started out of docks about 11 o'clock got map 3/- including Southampton missing Sherborne by about 3 miles³

2.2.1 The fact

Alan Turing, still a boy, cyclings along a route of 60 miles to reach Sherborne on the first day of school [3]. It is in this period that Turing began to show interest in science in relation to the secrets of nature and biology.

Turing dedicated to the study of the human brain and the electronic brain, researching the basic mechanisms of thought and reasoning [4].

2.2.2 The scene

A landscape, accompanied by real travel sounds reworked in musical form, is presented. The show and the entire scene come to life through the presence of a symbolic human-electronic brain, the sound generated by the mixture of digital sound elements (computer) and natural (the breath of an organ) emphasizes and amplifies the data produced by the heartbeat and the breathing of the actor.

2.3 Scene II – Turing Machine, 1936 Cambridge

³ A. Turing, *Letter sent to parents*, may 5th, 1926. Preserved in the Cambridge King's College archives



It had an infinite memory capacity obtained in the form of an infinite tape marked out into squares on each of which a symbol could be printed.⁴

2.3.1 The fact

At the age of 24, in his paper *On computable numbers*, Alan Turing processes the logical principles of what is now known as the *Turing Machine*, rationale and archetype of all the digital processors and the concept of software [5]. The technology historian George Dyson identifies in Turing the visionary architect protagonist of the Big Bang of the digital universe in which we live today.

2.3.2 The scene

An endless country road represents scenarios in which Turing, future marathoner, spent a lot of time running and thinking; this turns into the *Turing Machine*, infinite tape on which are written and processed data, symbols, movements and calculations; the actor plays a few passages from the article of 1936.

2.4 Scene III - Enigma/Bombe, 1939 Bletchley Park



⁴ A. Turing, *On Computable Numbers*, 1936

Dear Prime Minister, Some weeks ago you paid us the honour of a visit, and we believe that you regard our work as important. You will have seen that (...) we have been well supplied with the 'bombes' for the breaking of the German Enigma codes. We think, however, that you ought to know that this work is being held up, and in some cases is not being done at all, principally because we cannot get sufficient staff to deal with it... A. Turing, G. Welchman, H. Alexander, P.S.Milner-Barry⁵

2.4.1 The fact

During the Second World War, Turing is at the service of British intelligence in the secret headquarters of Bletchley Park, the main cryptanalysis center in the UK. His contribution is crucial to decipher the codes used in the German communications, encoded by the so-called system *Enigma*.

2.4.2 The scene

The real sound of *Bombe*, electromechanical Polish machine, implemented by Turing and essential for the decoding of *Enigma*, is the basis of the musical composition. The sound of a *Lancaster* bomber, electronically recreated with the Synthi, and the urgencies of the race against time described in the text of a letter to Winston Churchill [6, 7] are the basis of this scene, visually represented by a chess game⁶ played on the scenario of war through real messages and data submitted by U-boats⁷.

2.5 Scene IV – Delilah, 1944 Hanslope Park



Research on Delilah has been in progress since the beginning of May 1943. Up to now the work has all been concentrated on the unit for combining the key with the speech to produce cipher (or

⁵ A. Turing, *Letter to Prime Minister Winston Churchill*, October 21st, 1941

⁶ The chess moves are from the game played in Berlin in 1852 by Adolf Anderssen and his student Jean Dufresne

⁷ The decoded messages and routes come from the U-boat 79, 96, 264 and the Bismarck battleship

scrambled speech) and for recovering the speech from the cipher with the aid of the key⁸

2.5.1 The fact

Alan Turing had been sent by the British Government in the United States for a comparison with the American security experts on coding systems used by the Allies. Back from America, after examining the monumental SIGSALY, voice coding system used for communications between Churchill and Roosevelt, Turing gives another great example of his vision and simplification creating *Delilah*, which, although it has never been used in operations during the war, is the first example of digitization of the voice [8].

2.5.2 The scene

In this scene the digitization of the voice is artistically recreated through computers and the Buchla synthesizer. The voice of Churchill, part of his speech of March 26th, 1944 [9], used by Turing to test *Delilah*, the voice and the image of the actor on stage are developed in a process of sound rarefaction and granulation and visual decomposition that reworks the image's decoding errors.

2.6 Scene V – ACE, 1946 London NPL



2.6.1 The fact

The *Automatic Computing Engine* (ACE), designed by Turing in 1946 [10], introduces many modern ideas used in computer science, such as the concepts of subroutines, the search for extreme speed calculation, memory-resident programs. Immediately after the war, left Bletchley Park, Turing worked for a few months to ACE at the National Physical Laboratory in London (NPL). For bureaucratic reasons more than anything else the first working model of ACE will be realized only in 1950, when Turing has now left the NPL and in the world similar computers will have been made.

⁸ A. Turing *Delilah Report*, June 6th, 1944 – British National Archive, box HW 62/6

2.6.2 The scene

This scene is dedicated to sound and visual research. Self-generating algorithms represent, in video, the computer. The interweaving with the music that is developed from the basic concepts of computer (delay lines, search for computational speed, memory-resident programs implemented through the use of about 800 valves), starts from a single square wave until you get to a complex organism at both polyphonic musical and tone sound level, through lines of counterpoint that overlap themselves, sudden changes in the scenario, in an expansion that takes the audience directly to the Morphogenesis.

2.7 Scene VI – Morphogenesis, 1950-1951 Manchester



2.7.1 The fact

Between 1951 and 1952, Alan Turing developed a study on the biological Morphogenesis [11]. He supposed that the biological patterns more widespread in nature (the spirals of snails, the leopard spots, skin pigments) were formed with rules related to the numerical sequence described by equations. It was theoretical speculations, but years after the death of Turing, it was discovered that in most cases it fitted the facts.

2.7.2 The scene

To describe the Morphogenesis, Turing proposed differential equations that are used in the show for an autogenerated activation of music and video. Compared to the previous scene, here prevail the image of pattern multidimensional structures that interact in real time with the progress of music.

2.8 Scene VII – Communication – Information

2.8.1 The fact

Science historian George Dyson says: “humanity has put into operation the first computer, a digital universe made up of only

5 KB of memory, the equivalent of half a second of MP3 music”⁹. It's the Big Bang of the digital universe, a system in which human time and the time of the machines intersect and give rise to the complexity of information in continuous and fast expansion in which we are immersed every day.



2.8.2 The scene

In this scene the Big Bang and the relationship between digital Turing and time, Kronos, take shape: in the multiple representations, human and machines time, analog and digital, historical and life urgencies, collective time and private time.

The *laser pendulum*, through optical sensors connected to computers and laser light, produces sound effects and mathematical harmonics, time oscillations and sound and visual waves that interact and accompany the temporal path of Turing and the movements of the actor. The musical composition starts from the sound of the 56k modem, which represents, in the collective imagination, the entrance to the era of the Internet.

2.9 Scene VIII – Turing Test , 1950 Manchester



I propose to consider the question, ‘Can machines think?’ This should begin with definition of the meaning of the terms

⁹ G. Dyson, *Turing's Cathedral: the origins of the digital universe* Pantheon Books, 2012

'machine' and 'think'. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. (...) The new form of the problem can be described in terms of a game which we call the 'imitation game'. It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. (...) The object of the game for the interrogator is to determine which of the other two is the man and which is the woman¹⁰

2.9.1 The fact

The most famous legacy that Turing has left in artificial intelligence is the Turing Test, published in 1950 [12]. Turing proposed, through the formulation of simple questions, a criterion to define whether a computer or any machine could be considered "thinking". The Turing Test has been repeatedly criticized and reworked, but still no machine has demonstrated its ability to overcome.

2.9.2 The scene

"The imitation game" takes form. A man X and a woman Y offer the audience a mirror dance to involve them in the process of imitation, then they take place behind two screens, to be unrecognizable to the character of Turing that will start the test.

The original test provided that competitors would respond to the questions by typing, unseen by the questioner. The shadows of the players will activate the answers to the test that will be displayed on the screens. A line from *Twelfth Night* by Shakespeare, in response to a question, is a tribute to the incredible ability of Turing to communicate the science. The test is here proposed without changing any of the passages of the writing of Alan Turing.

2.10 Scene IX – The chess game



2.10.1 The fact

In 1948 Turing realized *Turochamp*, an artificial intelligence software. He made a simple algorithm to be used to instruct a

¹⁰ A. Turing, *Computing Machinery and Intelligence*, Mind 1950

computer to play a game against a man. But he was defeated by his own intellect. He lost by abandoning the game and the Queen won.

2.10.2 The scene

In this scene the game of chess returns as a metaphor for life. The moves are those written by Turing¹¹. For the first time Turing and Kronos look into their eyes. Turing run after and precedes the pendulum until the victory of the Queen, which brings us to the next scene.

2.11 Scene X – The trial 1952 Wilmslow



*I am both bound over for a year and oblie to take this organo-therapy for the same period. It is supposed to reduce sexual urge whilst it goes on, but one is supposed to return to normal when it is over. I hope they're right. The psychiatrists seemed to think it useless to try and do any psychotherapy...*¹²

2.11.1 The fact

In 1952, Turing went to the police to report the robbery by a friend who he hosted in his house. From this complaint, the British authorities came to the conclusion that Turing usually entertain homosexual relations and arrested him. He was tried, convicted of lewd act with a male person and sentenced to be subjected to a hormone treatment.

2.11.2 The scene

"The Queen versus Alan Turing"¹³, with the reading of the sentence, the action begun under previous scene continues. An avatar, twin of Turing and inhabitant of the digital universe,

¹¹ The moves of the chess game come from the game written in 1952, following the rules of the software, by Alan Turing, played in Manchester with his friend Alick Glennie.

¹² A. Turing *Letter to Philip Hall*, April 17th 1952, ref. Andrew Hodges, Alan Turing The enigma

¹³ Trial judgement published April 4th, 1952, on Aderley Edge Wilmslow Advertiser.

gives images to the physical and emotional effects of the hormone treatment on the body of Turing.

2.12 Epilogue



2.12.1 The fact

On June 7th, 1954 Alan Turing was found dead, poisoned by cyanide of potassium.

2.12.2 The scene

The actor leaves the stage, the breathing of Turing continues, death is represented by a group of music and video in a narrow process of interrelation. The sounds produced by an organ, in particular those of the time of the emptying of the barrels, reworked in electronics, fill the barrels, represented on the screen, up to the time of exhalation, displayed with the emptying of the barrels. On the screen appears a brain, a symbol of what Turing left us: the primordial breath of today's digital world.

3 TECHNICAL DESCRIPTION

3.1 Introduction

In a show in which there are a lot of audio and video, fixed media and real time synthesis/elaboration made by several computers, and every single musician has a personal (more or less) complex hardware/software digital environment for his performance, the first thing to face was the design and the implementation of a software capable to control the various single units as a whole.

To do this, we divided the system into two conceptually different treating signal units: synthesis/elaboration signals and control signals, every single unit interconnected via OSC [13] in a network by an Ethernet switch.

The main computer was in charge of the events cuelist, sending control signals to the independent computers doing the hard computational work for the audio and video, and acting also as a warden controlling signals generated from whatever of the performer's computers for whatever else.

A secondary subdivision was made for the audio and video computational units and their audio and video signals feeding respectively the beamers and the audio diffusion system.

In scene there were an actor, four electronic music performers, a keyboard player (just in the epilogue) and a video performer, plus a sound director.

3.2 Description

We now briefly analyse the technical setup of every performer, starting from the video.

We have a MacBook Pro running a Quartz Composer custom made patch in which we can control various video generation and/or elaboration parameters via a MIDI control surface (a Novation one) connected via USB and with the output video signal sent to a Matrox triple head feeding three 10.000 AL 1920x1200 beamers vertically disposed. At some point during the play Processing¹⁴ was used with a script for the visualisation of Turing's morphogenesis differential equation in the McCabe implementation [14], in which a couple of parameters are dynamically controlled by a gate and an envelope follower in the audio patch.

A first audio performer setup is build around a MacBook Pro running an Ableton live with max for live session, controlled via an iPad running Lemur (in a private local wifi network) and three MIDI controller via USB. A software sampler is running in this computer too, controlled by a MIDI master keyboard, this latter played by another performer. Finally, a MOTU 828 audiocard sends 8-channels audio to the stage console.

A second audio setup is build around two synthesizers, a glorious EMS Synthi and a Buchla 200e, whose signals are sent for further elaboration to a macbook pro running a custom made maxMSP program controlled by a MIDI surface control (another Novation). This computer was used for the actor's voice elaboration too: in this case we wrote a special granulation patch. An RME fireface audiocard output 8-channels audio to the stage console.



The third audio setup performer manages the main cuelist, with a custom made maxMSP patch controlling the fixed media playlist via a MIDI controller, the OSC network and the overall

¹⁴ Processing is a programming language, development environment, and online community available at www.processing.org

speed of the performance via a sensor in the actor's body sending his heartbeat sound and velocity during the play. There are two other computers, one running Synapse for the body detection/kinect signals and a max patch sending these control signals to the OSC network, and another one with the audio software for the laser harp (a MIDI max patch for Kontakt sampler). Besides, this performer manages the stage console, a Yamaha DM1000 with two digital cards.

The fourth setup consist in a 30 meters long 11-beam laser harp, whose rays are crossed by a multipendulum with different length arms, and so generating different time periods. The interruptions of the laser beams generate sounds and musical notes, and the player have a way to change timbre and scales by varying the duration of the interruption. This implementation of a laser-harp is totally new from the existing models, designed and prototyped by our own.



At last, the actor can trigger with his movements - captured by the kinect - some samples and audiofiles as well as control some audio filtering treatments when in front of the kinect device, whose signals are also used to create a virtual avatar by the video computer.

The main console consist in a Yamaha DM2000 digital mixer equipped with three digital cards, connected with the DM1000 stage console in a Rocknet Network and sending 18 discreet digital audio channels to a Motu Traveler audiocard for the recording of the play in a Logic Pro session in another MacBook Pro and 22 discreet audio channel to the PA system.

The sound director here had the complete responsibility of the sound of the multimedia play, because this console gathers together the audio signals of every electronic musician and projects them on the space on a PA system disposed all around and above the audience, and in the backstage too: in the theatre were installed some 23 independent loudspeakers and 4 subwoofers.

4 SHOW CREDITS

Project and direction

Maria Elisabetta Marelli

Implementation of computer technology and live electronics

Massimo Marchi

Music

Sandro Mussida, Pietro Pirelli, Giorgio Sancristoforo, Michele Tadini

Sound direction

Hubert Westkemper

Video

Claudio Sinatti, Stefano Polli

Alan Turing

Alessandro Bruni Ocaña

Clothes

Roberto Urban.0 Brancati

Expert consultant

Giulio Giorello

Laser harp design and engineering

Francesco Murano, Giampietro Grossi, Pietro Pirelli

Photo

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TURING a staged case history it's a multimedia action performed in 2012 at Piccolo Teatro of Milan, Italy. Written and directed by Maria Elisabetta Marelli and produced by AGON, in collaboration with the **Italian Ministry of Heritage and Culture** and the **Municipality of Milan**. The show was been included in the calendar of international events in 2012 **The Alan Turing Year – A Centenary Celebration of Life and Work of Alan Turing**.

REFERENCES

- [1] M. E. Marelli, *TURING a staged case history*, 2012 www.turingcasehistory.net
- [2] A. Hodges, *Alan Turing: the Enigma*. Random House 2012
- [3] A. Turing, *Letter sent to parents*, may 5th, 1926,. Preserved in the Cambridge King's College archives.
- [4] Edwin Tenney Brewster, *Natural Wonders*
- [5] A. Turing *On Computable Numbers*, 1936
- [6] A. Turing and his Bletchley Park partners *Letter sent to Winston Churchill* October 21th, 1941. Kept at Kew Public Record Office, Richmond, Surrey – HW 1/155
- [7] W. Churchill draft October 22nd, 1941. Kept at Kew Public Record Office, Richmond – HW 1/155
- [8] A.M. Turing, *Speech sistem Delilah*, Report 1944/6/6. Kept at British National Archive, box HW 62/6
- [9] W.Churchill *Our greatest effort is coming*, speech (Vital Speeches, Vol. X) trasmitted by radio in March 26th 1944
- [10] A. Turing, *Progress Report of ACE*. NPL, London, April 1948
- [11] A. Turing, *The Chemical Basis of Morphogenesis*, Philosophical Transactions of the Royal Society of London (Series B, Biological Sciences, Vol. 237, No. 641), August 1952.
- [12] A. Turing, *Computing Machinery and Intelligence*, 1950.
- [13] M. Wright, A. Fried, *Open Sound Control: A New Protocol for Communicating with Sound Synthesizers*, Conference Paper, ICMC 1997
- [14] J. McCabe, *Cyclic Symmetric Multi-Scale Turing Patterns*, Conference Paper for Bridges Conference 2010