

NOTEBOOK "COMPUTATION, ANALOGUE AND TIME-DISCRETE COMPUTING"

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NOTES ON ANALOG COMPUTING

The "post-computational" has been the pre-computational: analog computing

- "analog computer" not simply mimicking the physical behaviour of the real world; analogy derived from a common mathematical analysis of both real physics and the physics of the analog computer: simulation based on the mathematical equivalence of analog electronics to dynamic beings in the world; epistemology of electrical analogies (Charles Care)
- contemporary media culture almost automatically identifying "the computer" with digital computing; analog computer as apparatus not simply a dead end in the history of calculating technologies; taken as a method, analog mathematical modelling and continuity (the core of analog computing) remaining a radical alternative to algorithmic computation
- Simondon conceptualizing evolution of *analog* technical devices (technological individuations); different for computational machines; analog (and therefore as well future quantum-)computing making a decisive multi-valued difference
- "post-computational" not (only) quantum computing and hypercomputation but a re-turn (recursion) of analog computing; conventional philosophy rather not adequate for analog signal transducing technologies (electro-engineering); different with techno-mathematics; two deeply philosophically routed disciplines, mathematical reasoning and philosophy of technology, here merging
- scientific experimentation by computing usually associated with the digital computer, where the mathematical algorithm is a model of the physical event to be simulated; on the contrary, simulation by analog computers performing mathematical simulation by (electro-)physical means itself
- simulation when the material object not even yet exists, such as the simulation of a nuclear reactor by analog computing
- analog computing: material elements which embody certain mathematical structures like integration and multiplication coupled according to a model analogous to the simulated object; analog machinery not a metaphysical, intransitive abstraction from the world (a "language"), but part of physics itself
 - physically real, mostly unaccessible world to what can be perceived by human (measuring) senses, as defined by Max Planck; technology man-made, thus: culturally variable
- analog computing *not* computation; message of analog computing: doing mathematics in the engineering way (different from Claude Shannon's mathematization of engineering)

- in analog computing interface differing from numerical computing (until the graphical user interface turned the digital computer itself into a quasi-analog machine - on the surface)

- analogisation not a construction of cultural knowledge, but an implicit knowledge from within nature itself; amazing analogous behaviour of a swinging pendulum (a mass, suspended at a lever) and a "Schwingkreis", an electronic short-circuiting of induction (coil) and capacity (condensers); Fig. 1.1 and fig. 1.2 in: Giloi / Herschel o.J.: 12; syllogistic "medium term" of both operations, mechanical and electrical, is a mathematical differential equation: Fig. 1.1, *ibid.*, 11

- "One of the most powerful applications of analog computers is simulation in which physical properties, not easily varied, are represented by voltages which are easily varied. Thus the "knee action" of an automobile front wheel suspension can be simulated on an analog computer in which the weight of the automobile, the constant of the spring, the damping of the shock absorber, the nature of the road surface, the tire pressure and other conditions can be represented by voltages. In practice these factors cannot be readily changed, but on the computer any one or all of these may be varied at will and the results observed as the changes are made. Analog computers are especially useful in solving dynamic problems in which the motion can be expressed in the form of a differential equation" = Operational Manual for the Heath Educational Analog Computer Model EC-1, 3

- simulation as performing experiments on a *model* in order to gain insights into the physically real, modelled system; today in most cases this modelling is computer simulation

- philosophy of software tools like *Simulink* (a derivative of the radically matrix-based mathematical tool *Matlab*, a commercial product of *The MathWorks*) differing from previous generations of simulation software, in that it is time-based simulation, and *Stateflow* which is event-oriented simulation; such software is based on signal processing itself, thus respecting the micro-temporalities of signal behaviour itself. Signals are temporal events, defined as "the variation through time of any significant physical quantity occurring in a useful device or system [...] a time-varying quantity" = Edward B. Magrab / Donald S. Blomquist, *The Measurement of Time-Varying Phenomena*, New York et al. 1971, 1. Whereas an emulation re-enacts the functions of an object, simulation rehearses its temporal qualities (*Eigenzeit*) as well

- different from purely material (archaeological) relics from the cultural past which are subject to physical erasure and entropy, symbolically encoded information - which is the essence of digital computers and has been the cultural technique of preserving musical information despite the evanescence of acoustic articulation - ideally / almost time-invariantly transmitted to posterity. "Consequently, the EDSAC simulator is textual rather than artifactual in spirit. [...] the attention that other projects have given to physical authenticity has been directed at obtaining authentic program texts. [...] as with musical scholarship, this textual approach permits the informed and explicit filling in of lost textual fragments" = Campbell-Kelly 2000: 399

- on "reenactment" Collingwood's 1928 lecture "Outlines of a Philosophy of History", in: R. G. Collingwood, *The Idea of History*, Oxford 1946 (rev. edn. 1993), 440-443

Analog computing for / as simulation

- temporal behaviour (the "time-window", be it real-time or delay) a criterium for the definition of simulation

- message of analogue computing experimentation: doing mathematics in the engineering way, but different from Claude Shannon's mathematisation of engineering

- analog computing different from numerical computing (until the graphical user interface turned the digital computer itself into a quasi-analog machine - on the surface

- analogisation between physics and the analogue computer not a construction of cultural knowledge, but an implicit knowledge in nature itself. Again and again scientists have been amazed by the analogous behaviour of a swinging pendulum (a mass, suspended at a lever) and a "Schwingkreis", an electronic short-circuiting of induction (coil) and capacity (condensators): Fig. 1.1 and fig. 1.2 in: Giloi / Herschel o.J.: 12

- syllogistic common denominator of both operations (mechanical and electrical) a mathematical differential equation

- simulation defined as performing experiments on a model in order to gain insights into the physically real, modelled system; today in most cases this modelling computer simulation

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- temporal behaviour (the "time-window", be it real-time or delay) a criterium for the definition of simulation

- time axis manipulation not easily performed with purely physical, electro-technical mechanism. "Der Erkenntnisvorteil von Simulationen liegt in ihren Extrapolationsmöglichkeit für Bereiche, die zu klein oder zu groß sind, zu schnell oder langsam ablaufen" = Gabriele Gramelsberger, *Im Zeichen der Wissenschaften*, in: Gernot Grube / Werner Kogge / Sybille Krämer (Hgg.), *Schrift. Kulturtechnik zwischen Auge, Hand und Maschine*, München (Fink)

2005, xxx-xxx (448 f.) - chrono-morphing experimental events or even creating "events" which otherwise have not been perceptible to human senses.

NOTES ON MACHINE(-)WRITING AND TIME-CRITICAL COUNTING

Still human? Counting and adding

- alphabêtise (Lacan); "reading" with a scissor in hand, cutting redundant text passages down to its relevant, recombinable pieces. "It is entirely possible to build something without understanding it" = George Dyson, *The Third Law. The future of computing is analog*, in: *Possible Mind: Twenty-Five Ways of Looking at AI*, edited by John Brockman, Penguin Press, 2019; quoted here from <https://medium.com/s/story/the-future-of-computing-is-analog-e758471fbfe1>, accessed February 25, 2019 - which is Gödel's procedural mathematics, and Turing's symbol-manipulating machine.

- human hands enabling tasks resulting in cultural techniques (Leroi-Gourhan); elementary fingers which literally lead to digital counting in its most basic form: adding to ten decimal numbers

- intuitive tuning instead of exact counting: operating the slide rule; difference between machine and instrument; adding without numbers

- mechanical mathematical operation. "Adding" to which all computing can be reduced is a kind of archaic symbol operation: when counting, humans are in a machine state; adding with fingers not simply a cultural technique any more (defining culture as symbolic act), but already an externalization of the animal (body). The media-archaeological approach removes the borders between human and machine: with the counting hand already as "extension" of man, as prosthesis, as first media coupling of the body

- mechanical "adder" mechanism: fig. "mechanische analoge Addierwerke" in: Pflüger 2005: 30. Pflüger asking "ob der Computer überhaupt 'rechnet'"; rather: "symbol manipulating device", operating on binary symbol chains. Rather information processing in terms of entropy (Shannon); "Rechnen im herkömmlichen Sinn stellt dabei nur eine operative Möglichkeit unter anderen dar." Opening the notion of computing.

- treating binary discrete electronic states as "numbers" an arbitrary symbolisation; binary computer: counting with integers; analogue computer: real numbers

Back into counting

- humans counting (adding) numbers by fingers; binary computer, on the contrary, adds numbers by gates, derived from Boolean logics: digital-electronical circuitry for adding binaries; the logical and mathematical implications; cp. *analog*-electronical adding circuitry: physical voltage, or even more basic: analogical adder with wire ropes (Lego or Fischer Technik)

- no "GO TO" for "for / while"

- computer the operative entanglement of logics and matter: therefore it counts rather than narrates - close to "machine language" (Assembly) where algorithmics precedes narrative

- digital computer (on silicium chip) not counting with positive or electric electrons (0 / 1), i. e. charges (Ladungen) but with electric force (voltage / Spannung). "0" symbolizes not a single electron but a whole assemblage, sufficiently different in numbers from symbolical "1" = significantly other voltage (ex-5 V, now: 3,3). Statistical rather than exact amount - the opposite of what adding of whole numbers (integers) appear as on the symbolical level. There is no truly "binary" adding but physically fuzzy numbers of electrons (like electron "shot" effect in vacuum tubes as binary switches). Becomes critical only on the quantum-computing level

- addition / counting time by seconds: clock mechanism; Mumford, *Technics and Civilization*, 1934 / 1963

- UNIX time, atomic time clock (PTB Braunschweig), "broadcast" via DCF77: decouples "cultural" time from natural astronomical time, creating anachronisms which are compensated by leap seconds. A media-epistemological moment: cultural techniques of time-keeping transform into trans-cultural technologies. Within the computer, there is both a physical clock (called "realtime clock", hardware: quartz oscillator) and a logical clock (software); computing turns time-measurement into information, resulting in "multiple times" = Jeremy Rifkin, *Uhrwerk Universum. Die Zeit als Grundkonflikt des Menschen*, Munich (Kindler) 1988 [A0 Time Wars, 1987], 134, referring to David Bolter, *Turing's Man*

- according to Helmholtz, inner ear acting as a Fourier analyser; computing (analog / digital) within hearing; electronic non-human voice synthesis nothing but another version of what is inside the human understanding already where the physiology of hearing privileges "musical", i. e.: harmonic sensation; Ferdinand Trendelenburg, *Klänge und Geräusche. Methoden und Ergebnisse der Klangforschung, Schallwahrnehmung, grundlegende Fragen der Klangübertragung*, Berlin (Julius Springer) 1935, 13

- central register named ›Accumulator‹ in early-Mikroprozessors (8-Bit-Prozessors) like Z80, where arithmetic and logic operations take temporarily place

The "gesture of programming" (with Flusser)

- media-archaeological devices from early electronic computing to demonstrate how hardware to perform discrete numerical operations - nowadays almost exclusively be associated with integrated circuitry - literally transferred from a voice communication technology, such as manual telephone switchboard

- Flusser on "gesture" of telephoning; concentrates on dialling. In the analog mode, numbers from zero to nine which can be dialled not manually but usually

by the index finger. The meaning of "the digital" in current media culture refers to computer-based technologies. More precisely, the real "message" of the digital (in McLuhan's sense) is the binary code - which in fact reduces the hands with 10 fingers (Latin *digitus*) to just two micro-movements of on/off gestures. This is bound to decimal arithmetics (logarithm basis 10) which shifts to logarithm basis 2.

- the hand "human" at all, or half way to a machine (mechanism) already, an interface in the technical sense? uncanniness of the hand: humans not sure any more - faced with robotic and other prosthetic "hands" - that this is an integral human body part, its extension of even its autonomous brain-hand-system in the cybernetic sense

- doing things symbolically ("machine notation", with Babbage) vs. wiring / patching manually, close to the "real" of hardware

- "Archaeological *data* consists of recorded observations. These might be measurements of the size of a handaxe, the stratigraphical relationship between two layers or the geographical location of a site. Whilst archaeological data is frequently numeric, it can equally well be non-numeric, such as the name of the material or colour of a object. It also comprises visual data, such as photographs, plans or maps" = J. D. Richards / N. S. Ryan (eds), *Data Processing in Archaeology*, Cambridge U. P. 1985, 1 f.

Proto-programming

- archaeology of Russian computational thinking not restricted to paper-based research in State archives or explicit oral history interviews, but implicitly embedded within the remaining machines themselves

- "After American weapon factories during the Civil War had already delivered guns which exchangeable parts, World War One extended the exchangeability of guns like the notorious 08/15 to an extent that its single parts could be produced in bicycle and typewriter factories as well. Only such really modular systems, as having been claimed by Babbage for his proto-computer already, inaugurated the option of programmable hardware to a limited degree [...] while a digital computer can be structurally programmed" = Friedrich Kittler, *Hardware, das unbekannte Wesen*, in: *Lab. Jahrbuch 1996/97 für Künste und Apparate*, edited by Academy of Media Arts, Cologne 1997 (Walther König), 348-363 [transl. W. E.]; Michael Conrad, *The Prize of Programmability*, in: Rolf Herken (ed.), *The Universal Turing Machine. A Half-Century Survey*. Hamburg-Berlin 1988

Computing symbols

- "The length of numbers in binary notation is at least double that of numbers in the decimal system [...]. This makes the binary system impractical for human calculators, but it does not upset computers in the least. From the computer's point of view, these sequences of 1 and 0 are convenient, for they are easily codified in electric signals; the passage of current expresses 1, its interruption

0" = Denis Guedj, Numbers. The Universal Language, xxx (Thames & Hudson) xxx, 59

- computer processing whatever can be reduced symbolically to a set of numbers and (electro- or otherwise physically) really to sufficiently distinctive binary states

- *operational* machine always already trans-symbolic

- non-verbal, diagrammatic and algebraic language describing the technical transfer of speech by pulse code modulation (analog-to-digital sampling, different from FM) not philosophical but techno-epistemic in the most precise sense = B. M. Oliver, J. R. Pierce, and C. E. Shannon, The Philosophy of the PCM, in: Proceedings of the Institute of Radio Engineers vol 36 (1948), 1324-1331

Human and / or media-archaeological moments: computing

- pressing a key on a computer keyboard usually associated with some kind of symbolic meaning, as part of a word, a sentence, forming longer sections etc., which consequently then gets displayed on our computer screens, making us able to read it. But, through a media archaeological viewpoint, the keyboard sign is transformed into a electro-physical signal, thus loosing all its semantic referentiality and becomes a coded element, an electrical signal, within a physical computer, loosing the traditional symbolic meaning and gaining electro-physical indexicality. This introspective of the "algorithmic sign" (Frieder Nake) induces a more diverse understanding to the relationship between encoded symbols and their physical manifestation - a non-discursive, algorithmic configuration of the alphabetic symbol as signal events. The symbols loose their semantic meaning and become electrical indexes that have a new meaning and application inside the electro digital circuitry.

- for FlipFlop circuit as signal event to happen, not necessary to know the genealogy of this technological device; the technical event functions like an analog version of the Markov chain: probabilities of immediate future behaviour is dependent only on its present state

- "calculating machine" post-human (Kittler) or rather intra-human (Turing 1936 / Lacan)? cultural or equi-primordial (implicit) knowledge? Krämer, *Symbolische Maschinen*, 4: Genealogy of logical formalisation "in der wir gelernt haben, uns beim Operieren mit Zeichen so zu verhalten, als ob wir eine Maschine seien." While for Kittler elementary cultural techniques are absorbed in technologies, Krämer still defends habituation: "Eine Kulturtechnik ist für eine Praxis, die so transparent ist, dass sie nicht mehr bewusst erkannt wird" = Arndt Niebisch, Die Liebe zur Ziffer. Positionen einer posthumanen Philologie, in: Pál Kelemen et al. (eds.), Kulturtechnik Philologie, Heidelberg (Winter) 2011, 163-183 (177), paraphrasing Krämer; *dissimulatio artis* in rhetoric

- theoretical distinction by Jacques Lacan, the real, the symbolic, and the imaginary: "We learned to read RSI as gramophone, typewriter, and film" = Axel Roch, Hegel is Dead: Miscellanea on Friedrich A. Kittler (1943-2011), in:

Telepolis (November 17, 2011); <http://www.heise.de/tp/artikel/35/35887/1.html> (accessed June 26, 2017)

Both discursive and nondiscursive: "Media archaeology of the stack"

- stack a) "an operative structure that exists materially within the program code of software systems" = Rory Solomon, Last In, First Out. Network Archaeology of/as the Stack, in: *online* magazine Amodern no. 2 (2013), thematic issue "Network Archaeology", <http://amodern.net/article/last-in-first-out>; b) "a class of diagrams" (Solomon) which only come into being / become dynamic when time-operations by electric biasing (Zachary Dempster)

- physical media channel as nondiscursive infrastructure for the passage of discursive enunciations; triodes / transistors as discrete media channel?

- physical hardware and hidden data processing algorithms of computational media as subsemantic layers, *both* discursive (source coding) and nondiscursive (operationally implemented)

Digitality instead of the whole "hand"

- digital "sampling" ("Abstasten") - the central momentum in the conversion of analog signals in the physical world to numerical computing - corresponding with the discretization of the human hand into single "fingers" (Latin *digitus*); for Marshall McLuhan, even the cathode ray in the television tube is a "scanning finger" which is a *massage* to the retina in the human eye. With McLuhan's extension of the "haptic" qualities and of tacility to *all* senses (not just the finger tip), all of the sudden, even if he seems to have neglected the emerging computer as medium, he is a media-archaeologist of the "digital": "Our very word 'grasp' or 'apprehension' points to the process of getting at one thing through another, of handling and sensing many facets at a time through more than one sense at a time. It begins to be evident that 'touch' is not skin but the interplay of senses" = Marshall McLuhan, *Understanding Media*, New York et al. (McGraw-Hill) 1964, 60

- difference between the nature of haptic (acoustic) and electro-magnetic (visual) signal sensation matters. While Aristotle could not admit a self-induced signal transfer like it happens since James Clerk Maxwell discovered the nature of electro-magnetic wave dynamics, he had to suppose a fictional medium called "ether"; for the Aristotle all signal transmission happened in a material, almost haptic medium (*to metaxy*)

- for age of electricity, McLuhan identifying return (reoccurrence) of the primordial (oral language-controlled) "tacility". Its decisive criterion is its (almost) instantaneous speed of transmission. With electric media - not to be confused *electronics* and with strictly more "digital" electronic computing - begins the technical formation of tactility = Till A. Heilmann, *Digitalität als Taktilität. McLuhan, der Computer und die Taste*, in: *Zeitschrift für Medienwissenschaft* 3, no. 2 (2010), 125-134 (128)

- correlation between discrete arithmetic numbers / cultural technique of counting with fingers: "All of these anticipate later electric forms because, like the digital computer with its multiple yes-no dots and dashes, they caress the contour of every kind of being by the multiple touches of these points. Electricity offers a means of getting in touch with every facet of being at once, like the brain itself. Electricity is only incidentally visual and auditory; it is primarily tactile" = McLuhan 1964: 247 f.; electric current stroke / impulse; pointillism, Morse code) pre-figuring digitality; sampling of analog signal qualities (image telegraphy / television) = Heilmann 2010: 131

- Henry Fox Talbot envisioning, with chemical photography, the liberation of visual art from the painterly hand. "[...] photography made people realize that art was not necessarily the manipulation of a plastic substance like paint or materials of any kind. It is an act of selection, you press the shutter" = Jonathan Benthall, *The Computer as Medium*, in: Rosen (ed.) 2011: 461-465 (461); in unexpected recursion, artistic hand coming back to the picture, but not in a painterly mode any more: "The artist no longer directly touches or manipulates color, material, or objects. He or she manipulated algorithms, which are more or less abstract" = Abraham A. Moles, Introduction to conference *Computers and Visual Research*, Center for Culture and Information, August 3-4, 1968, Zagreb, reprinted in: Margit Rosen (ed.), *A Little-Known Story about a Movement, a Magazine, and the Computer's Arrival in Arts. New Tendencies and Bit International, 1961-1973*, Karlsruhe (ZKM) / Cambridge, Mass. (MIT) 2011, 263-266 (265)

- finger(s) on the Morse key / telegraphy; Heilmann 2010: 133: the world of the symbolic (order); counting with fingers / mathematization / mechanizations: "fingers-on", only two fingers: binary, typewriter MIGNON

- programming in *assembly languages*; these machine orientated languages „do things“ directly = "The Gesture of the Programmer" (Stefan Höltingen, abstract conference Brünn, 2014). In the sense of John L. Austin, they connect elements of hardware; they make the electrical signals flow in a distinct way through the circuits; and beyond all that their syntax and semantic stand for a theoretical model for the computer itself (Turing completeness). So the coder at the keyboard becomes much more than only a writer/author of code. He applies a theoretical "symbolical" machine to a physically real machine; programming forces the „universal Turing machine“ to become a „special purpose machine“ – only by using words from a special alphabet, the programming opcodes

Not hands, but fingers: the "digital"

- Jeron Lanier 1989: presentation of a "data glove"; immersion / reentry of "mani"pulation in form of the computer mouse / the pointer on the screen

- limited manual precision in analog computing with sliding rule; "on the other hand" infinite variability of "real numbers" which the digital computer always misses; Abakus: discretisation. Numerical computing turns the hand into fingers: "analysis" (elementarization) with which symbolic notation (alphabet / numerical mathematics) corresponds different from geometrical drawing

- hands on instruments: *soldering* as opposed to type-writing (and programming for digital mechanisms); in TM reduced to two "keys" (binary code / bit)

Hand-writing versus type-writer

- Nietzsche's use of typewriter inducing a different kind of reasoning; key-board of Nietzsche's Malling Hansen; animation of the transporting ribbon mechanism, clock-like; implicit Turing machine; analyse Nietzsche's typewriter (at the Weimar Classic Collection) by writing: an operative analysis, where any textual hermeneutics of the poems written by Nietzsche on this very machine cannot reveal his experience with the obstacles of the mechanism. It is in their operativity that technical media *time-critically* (crucially) unfold

- media-archaeological view of early printing culture: not appearance (the Gutenberg Bible emulates handwriting, with the previous medium being the "content" of the new one according to McLuhan's law of media); technology of identical (re)production: identical "letter" casts from matrix negative

- media revolution not printing as such (in fact the typography of the Gutenberg Bible explicitly aims at emulating the appearance of the illuminated handwritten manuscript - with the previous medium being to content of the following one). It is rather the hidden technology of identical casting of metal letters (not the writing as such) from a master mould which lead to a new technological mode of identical reproduction of textual knowledge (and printed illustration, giving rise to scientific knowledge exchange - as emphasized by Elisabeth Eisenstein's classical study on the Printing Press as an Agent of Chance). Once more, media archaeology rather focuses on the non-discursive technological pre-conditions of discursive knowledge in the Gutenberg era.)

- Russia and Persia around 1850 establishing telegraph lines on their territory to facilitate communication with the Indian sub-continent; lines suffering from heavy signal degeneration over space; therefore a readable telegram between London and Kalkutta was rather improbable through the agency of personnel with deficient language facilities; solution their replacement by non-human repeater-regenerators

Machine-writing

- term "manu-script" not relating to human hand-writing any more but the typographic original of the printed book = Peter Stein, *Schriftkultur. Eine Geschichte des Schreibens und Lesens*, Darmstadt (Wiss. Buchges.) 2006, 176

- alphabetic writing (McLuhan) pre-conditioning epistemology of analysis (elementary practice, combined with the eye: reading), *versus* "acoustic space" (returning with electricity)

- hand-driven phonograph / grammophone (Emile Berliner); the ear much more sensitive to unregularities. "Bei der Wiedergabe musikalischer Töne macht sich jede Unregelmäßigkeit bei der Drehung der Walze, die ja durch Handbetrieb erfolgt, unangenehm bemerkbar" = Report in *Leipziger Illustrierte* from 1878, quoted in: Herbert Haffner, "His Master's Voice". Die Geschichte der Schallplatte, Berlin 2011, 20

- hand-held endoscope / stethoscope in medicine *versus* ultrasound image; artefactuality of the camera objective

NOTES ON TIME-DISCRETE COUNTING AND TIME-KEEPING

Vibrating sense of time: between liturgy and machine

- "There is clocklessness, for sure, but no such thing as 'timelessness'" = Elena Esposito, Die Konstruktion von Unberechenbarkeit, in: Avanesian / Malik (eds.) 2016, 37-42; *vice versa*

- "time does not mean watches, clocks or the oscillations of caesium atoms, time is not found in digital pips or paper calendars, time is not in pendulums or in chronometers; the clock is not a synonym for time but the opposite of time. The West's obsessive time measurement has gone hypertelic" = Griffith 12; Bergsonian argument

- cultural history discovers tight relations between religion and technology, with a seductive force to reformulate religious practices in technological terms = concept "cultural techniques" vs. non-cultural, techno-poetical element at work which is being focused upon by the close analysis of the Anchor escapement mechanism of the oscillating clock. While originating from the late medieval monasteries, its technical logic resulted in time-based media processes which challenge historical narrative itself

- media-archaeological event level (analogous to Braudel's tri-fold paces of time / *durée*), the regime of non-discursive technologies with an inherent logics of its own; technologies - once they are operative - indifferent to the question whether they have been installed out of a religious bias or not, even if they bear the imprint of this bias in technical form

- instead of reformulating religious practices in technological terms (association between liturgy and algorithm), precisely ask what differentiates cultural techniques from genuine media technologies, insisting on the non-cultural element in technologies (their inherent auto-poetical logics); epistemological dis/continuity from religious timing to time-based media processes, resulting in an awareness of differential oscillations (Huygens, Mersenne, Leibniz et al.) which separate the Pythagorean cosmology from the electro-technical and techno-mathematical media age

- "Lewis Mumford has suggested that the clock preceded the printing press in order of influence on the mechanization of society. But Mumford takes no account of the phonetic alphabet as the technology that had made possible the visual and uniform fragmentation of time" = McLuhan xxx: 147; ancient Greek

interest in *cosmos* triggered insight into the relation between harmony and mathematics; phonetic alphabet gave a training in analytical thought (McLuhan); a sense of "beat" stems from the analytic discretisation of articulations as first practices by the phonetic alphabet but led to its automated implementation on by need of religious monastic culture. Against Christian teleological sense of temporal linearity (later replaced by "arrow of time" inscribed by the 2nd law of thermodynamics into physical processes), transcendent time became *timing* once implemented in *operative* media

- phonetic alphabet rather corresponding with mechanical cinematics in its technical meaning, like the clock-work of timing relates to the mathematical position system of numbers: "Just as a great revolution in mathematics came when positional, tandem numbers were discovered (302 instead of 32, and so on), so great cultural changes occurred in the West when it was found possible to fix time as something that happens between two points" = McLuhan 1964, chap. 15: "Clocks. The Scent of Time", 145-146 (145)

- "As a piece of technology, the clock is a machine that produces uniform seconds, minutes, and hours on an assembly-line pattern. Processed in this uniform way, time is separated from the rhythms of human experience. The mechanical clock [...] helps to create the image of a numerically quantified and mechanically powered universe" = *ibid.*, 146

- sense of periodic repetition culturally linked to liturgic practice but led to a rather non-religious take-off of oscillating mechanisms, from wheeled clock to "clocking" within electronic computing itself

Ruptures between cultural techniques and media technology

- technological inheritance not historically "past" but enduring: not *in*, but *as* inherent archive (Foucauldian *l'archive*) of techniques and material constellations

- oscillating clock a nonhuman mechanism which conditions the rhythm of human bodies and minds, replacing mythic or religious temporal rituals; escapement mechanism in wheeled clock an epistemogenic artifact which differentiates cultural techniques from genuine media technologies

- literally time-critical criterion which emancipates media culture from traditional cultural symbolism: time measurement breaks loose from natural temporal perception and becomes a matter of the automated setting of time, in a rhythm freed from allegorical interpretations; difference between letterpress and handwriting as an analogy for the transformation enacted by the wheeled clock. As mechanical instruments, both letterpress and wheeled clock possess a central characteristic of technological media: the identical reproduction of elementary units of measurement. In contrast to rituals and liturgy, mechanized time is no longer symbolically performative but rather technically operative; not time per se that is operative here, rather its implementation in a material artifact; Gutenberg's casting process for metal letters resulting in standardization of characters correlating with the wheeled clock in automation of temporal intervals

- Medieval Christian monasteries characterized by a peculiar representation of cyclical time (the liturgical year, the division of days into rhythms of prayer), resulting in need to regulate forms of living into liturgical "algorithms" by precisely quantified measurements of time in the form of hours of equal length (equinoctial hours); introduction of temporal beats an epistemologically fundamental inheritance of monastic culture, yet resulted in technically mediatized time, afterwards employed to undo cyclical time; mechanical beat became a criterion for literally separating medieval from modern time(s). Time, in this case, both subject and object of a media-archaeological *momentum*

Chronology, Clock, Rhythm vs. Monastic Planning of Time

- significant modification of monastic *clocking* mechanism by explicitly adding escapement. Even if this must have happened at once peculiar instance by an individual creative act, this still occurred anonymously in the media-archaeological sense. Gerhard Dohrn-van Rossum, *History of the Hour*, Chicago (University of Chicago Press) 1996: no explicit human intention manifested in the innovation of the "verge-and-foliot" escapement; in this key self-regulating mechanism that directed the motion of the late medieval wheeled clock, rather a techno-logics unfolds itself. In Benedictine monasteries, *a priori* no compelling interest in standardizing time through mechanically reproducible synchronization

- Leibniz may have subconsciously - according to his concept of *pétites perceptions* - had the binary pulsing of the ticking clock in his acoustic mind when he formulated his theological-mathematical dyad as a "wonderful origin of all numbers from 1 and 0, which offers a beautiful model of the mystery of creation, for all things originate from God and otherwise out of nothing: *essentiae rerum sunt sicut numeri* = Letter from Leibniz, 18 May 1696, quoted in Hans J. Zacher, *Die Hauptschriften zur Dyadik von G. W. Leibniz. Ein Beitrag zur Geschichte des binären Zahlensystems* (Frankfurt/M: Klostermann, 1973), 209

- becoming quasi-mechanical, human bodies disciplined and manipulated on the temporal axis; yielded a microphysics of power in the form of temporal rhythm; synchronized time measurement (as in the coupling of clockwork and photography, e.g., in chronophotography) ultimately facilitated a form of media-technical analysis of movement that would finally produce a re-synthesis, in the form of cinema

- "continuously ticking" (oxymoron) since the second half of the thirteenth century, the wheeled clock, equipped with a verge escapement mechanism that controlled the advancing gear train at regular intervals or "ticks", put into practice a negentropic dissection of the flow of time, analogous to the spatialization of the printing press. In lieu of the constant, analog character of the sundial indicator, the pulse of the mechanical clock was balanced through even intervals of the taut (and thus stored or potential) energy of a weight. As the verge escapement forced time constantly to expend itself, the seeming continuity of time was subdivided into even segments, a folding together of the analog and the digital; an early form of the binary implementation

(informatization indeed) of mechanical processes as they had been known ever since mill wheels; regulation based upon an interruption: kind of material embodiment of zero at the temporal level; Peter Gendolla, *Die Einrichtung der Zeit*, in: Christian W. Thomsen / Hans Holländer, eds. *Augenblick und Zeitpunkt* (Darmstadt: Wissenschaftliche Buchgesellschaft, 1984), 49; once zero was calculated as a gap (a condition of the positional notation system), clock ticked at regular intervals

- highly literate communities apt for accepting the fragmentation of life into minutes and hours = Marshall McLuhan, *Understanding Media. The Extensions of Man* (New York: McGraw Hill, 1964), 142; time conceived as something radically discrete: a virtual differential. However, "it was not until printing extended the visual faculty into very high precision, uniformity, and intensity of special order that the other senses could be restrained or depressed sufficiently to create the new awareness of infinity" = *Ibid*, 112; accompanied the idea of the research experiment, as well as the "concept of indefinite repetition so necessary to the mathematical concept of infinity," which ultimately culminated in Leibniz and Newton's infinitesimal calculus = *ibid*, 112

- static aesthetic of order in the concept of the cosmos becoming dynamic with the wheeled clock; with advancing precision, temporal intervals infinitesimally converging on zero; temporal perception thereby mechanically specified, and later cast by Newton and Leibniz into mathematics

- computer clocked by the ultra-fast oscillations of an electrically activated quartz crystal, down to units that escape human perception and that allow infinity to reappear in the infinitesimal

- ticking, wheeled clock signified that numbers were turning into machines (or that machines were becoming numbers), starting to prepare us for the advent of the Turing Machine, the modern computer of the twentieth century

- wheeled clock transforming Medieval "annalistic" macro-time into a microphysics of time

- Aristotle, in a techno-constructivist rather than phenomenological way (St. Augustin) defined time as motion to which numerical values can be assigned by measuring; concept of an estimated vanishing point in alliance with zero in mathematical calculation, producing a linear temporal perspective. With the advent of the wheeled clock, a rhythmic mechanism began subliminally to massage (in McLuhan's sense) the human sense of time, and its message came to be that the world could be perceived in terms of frequencies. The precise countability of time as movement (beginning with the ticking clock) eventually yielded world images such as those of film and line-synchronized electronic television. From this point, an advanced mathematical sense of time came into play: Leibniz' and Newton's infinitesimal calculus, which finally was related explicitly to the electronic media by Norbert Wiener = Norbert Wiener, *Cybernetics or control and communication in the animal and the machine* (Cambridge, MA: MIT Press, 1948)

- With its mechanical escapement, wheeled clock producing precise temporal beat in the form of a pulse sequence, with equal intervals; based on such

oscillations, machines later generate audible sounds in technical form; sonic existence came to take place as being in time; "ringing gradually begins to break away from the geometry of monochord proportions; music begins to leave the space of Greek mathematics, to plunge into the eventful dimension of time" = Wolfgang Scherer, Musik und Echtzeit: Zu John Cages 4'33, in: Zeit-Zeichen. Aufschübe und Interferenzen zwischen Endzeit und Echtzeit, eds. G. Christoph Tholen and Michael O. Scholl, Weinheim (VCH Acta Humaniora) 1990, 351-362 (356). This dimension can be called "media time." In his *Syntagma Musicum* (1614-1620), the organist Michael Praetorius related the symbolic order of the length of notes to the mechanical beat of the wheeled clock; Grete Wehmeyer, *Prestississimo. Die Wiederentdeckung der Langsamkeit in der Musik* (Hamburg: Kellner, 1989), 15

- metronome of Johann Nepomuk Maelzel (Vienna 1814), musical beat found its own medium, setting the terms on which the micro-time of physical acoustics would later become comprehensible through electro-technical measurement, "the necessary greater exactness [of which] is obtained by the electric current itself" = Hermann von Helmholtz, *On the Sensations of Tone as a Physiological Basis for the Theory of Music* [GO 1863], Whitefish, MT (Kessinger Publishing) 2005, 398; also Scherer 1990: 362. Ultimately, the electronic oscillatory circuit released the beat of time from all cosmic-religious remnants, in order itself to radiate in the ether.

- with development of the pendulum clock, mathematical counting of movement becoming autonomous, as a metronome to measure time; in 1377, Nicolas d'Oresme comparing movements of the celestial bodies with a wheeled clock in his *Libre du ciel et du monde* = Nicole Oresme, *Le livre du ciel et du monde*, edited by Albert D. Menot, Madison, Wi. (University of Wisconsin Press) 1968; specified the decisive element of the wheeled clock as the mechanical correlate to the ancient harmonic theory of the cosmos. Once set in motion by God, this system runs automatically. Even Leibniz conceived of his monads as clocks wound up by God: they "continued to keep time with one another like separate clocks, so that they appeared to communicate with one another; but this appearance is merely a deceptive consequence of their synchrony" = Norbert Wiener, *Time, Communication, and the Nervous System*, in: *Annals of the New York Academy of Sciences*, 50 (1948-50), 207; monads thus conceivable only *via* the wheeled clock as a standardized and standardizing instrument of measurement that also produced comparability in time. Norbert Wiener writes: "As a matter of fact, the automata made in the seventeenth and eighteenth centuries were run by clockwork," and today, more than ever, computing demands highly sensitive pre-existing temporal harmonies = *ibid.*

The Epistemogenic Artifact: the Wheeled Clock Escapement

- earliest mechanical clocks still retained principle of continuous driving force, such as water clock and in the water wheel. "It was about 1300 A.D. that the step was taken of momentarily interrupting rotary movement by a crown rod and balance wheel. This function was called 'escapement' and was the means of literally translating the continuous force of the wheel into the visual principle of uniform but segmented succession" = McLuhan 1964: 153

- "It was not the clock but literacy reinforced by the clock, that created abstract time and led men to eat, not when they were hungry, but when it was '*time to eat*'" = McLuhan 1964: 154

- in verge escapement of the wheeled clock, a technical mechanism became epistemogenic matter; description of the escapement's media-historical moment provides occasion to reflect upon some of the methodological implications of media archaeology; technically precise explanations carry epistemological weight; the art of media-archaeological (rather archaeographic) *ekphrasis* - comes into play; how escapement works: without such an intermittance, rotation of the axle would steadily increase in speed. "A crown wheel with an uneven number of teeth, mounted onto the axle or linked to it via a gear train, . . . alternately blocks and releases the verge by means of two pallets attached to the verge at a right angle to each other. . . . The duration of the oscillation of the inertial mass of the verge and the foliot can be adjusted by moving regulating weights on the foliot. . . . This to-and-fro, oscillating movement inspired terms for the device such like 'restlessness', 'foliot' (from a word describing a quivering leaf, first used by J. Froissart around 1370), even most metaphorically 'women's temperament'" = Dohrn-van Rossum 1996: 53; culture of the early modern period not only struggled with a new technology but also with a new language for describing it. Classical art of description had originated in rhetoric, based on linguistic figures; in contrast, new type of technological objects that emerged in early modern Europe demanded a new type of representation: the language of mathematics and of the technical diagram

- decisive feature of mechanical clockwork contained stored-up energy; spring tension produces pressure on the escapement mechanism, distributing minimal energy quanta into equal oscillations, which were then transformed mechanically into beats, placed on the border of pure information. Despite such a radical departure from existing clock technologies, introduction of the verge-and-foliot escapement barely mentioned in contemporary sources; only in retrospect described as "significant but mysterious", precisely because its mechanism could not be perceived at the interface of the clock face = Dohrn-van Rossum 1996: 46. Technical media achieve their effect by dissimulating their mechanisms: "In contrast, the appearance of striking clocks was registered instantly, and was felt to be technologically sensational and socially momentous" = *ibid.* Whereas the clock face can immediately be seen and heard, generating the effect of an advancing time, a glance at the escapement suggests an alternating oscillation rather than linearity; escapement thus constituted the first binary mechanism of positive/negative polarity, which ultimately became operative in electrical clocks and electronic clocking devices

- technological artifacts worthy of investigation in terms of their epistemic implications for media culture; every operative technology apt for media theory. Respective to their material substrates and logical diagram, technical media, like the science that studies them, not purely discursive events. In contradistinction with the objects of classical archaeology, medial-epistemic matters are logical as well as material artifacts. Technical media manifest themselves exclusively through their operations, placing logic next to hardware and making the term *techno/ology* meaningful

- first generation wheel clocks ticked rather imprecisely; uniform oscillations of the horizontal pendulum (the foliot-escapement with verge) independent of the precisely wrought wheelwork of the clock. Improvements in the accuracy of time measurement achieved with Galileo's discovery of the laws of pendulum motion in 1641 and with their application to the design of a free, vertically oscillating pendulum by Christian Huygens in 1656. Huygens's pendulum escapement established a new basis for measuring time: the periodic oscillation itself, which as a unit of measurement remained valid through to the invention of the atomic clock in the twentieth century, which approached the oscillatory operations of sensory data processing in the human brain = Ernst Pöppel, Die Rekonstruktion der Zeit, in: Hannelore Paflik (ed.), Das Phänomen Zeit in Kunst und Wissenschaft, Weinheim (VCH) 1987), 29 f.

- ticking wheeled clock not an allegory of time but a time machine; its presence acoustically indicated by the striking mechanism; because its technical mechanism in most cases remains hidden from the observer behind the clock face (*dissimulatio artis*, or concealment of technology, as basic techno-rhetorical figure of all media effects), requires media-archaeological attention.

- principal work of such a clock called, in a telling *terminus technicus*, "timework"; hour-striking mechanism (and deriving from it, musical compositions programmed *via* a cylinder with pins) controlled discretely / digitally. Otherwise, on the visible "analog" surface, motion of time appeared continuous. In the form of kinetic notation, the clockwork might be portrayed in diagrammatical terms: a kind of programming *avant la lettre*; Franz Reuleaux, Theoretische Kinematik. Grundzüge einer Theorie des Maschinenwesens, Braunschweig (Vieweg) 1875

On the Ritual and Liturgy of the Wheeled Clock: Media Archaeology versus Media Anthropology

- ticking clockwork resulting in an abstraction from cosmic time that could still be experienced empirically; mechanism of the verge-foliot escapement allowed the motion of a weight-driven axle to be controlled in such a way that its uniform rotation became suitable for use as a time standard such as the equinoctial hour in Benedictine monasteries = Dohrn-van Rossum 1996: 48; wheeled clock became a chrono-poietic (time-giving) instrument and established a time abstracted from nature. "For the first time in world history, mechanical reproduction emancipates a work of art from its parasitical dependence on ritual", Benjamin remarks on photography = Walter Benjamin, Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit, Frankfurt / M. (Suhrkamp) 1963, 17; also Jonathan D. Kramer, The Time of Music, New York / London (Schirmer) 1988, 68; such emancipation already occurred within the temporal regime

- ceremonial, ritual, rhythm, and repetition all cultural techniques for making time symbolically steady = Hartmut Böhme, Vom Cultus zur Kultur(wissenschaft). Zur historischen Semantik des Kulturbegriffs, in: Renate Glaser and Matthias Luserke, eds., Literaturwissenschaft - Kulturwissenschaft. Positionen, Themen, Perspektiven, Opladen (Westdeutscher Verlag, 1996, 55; culture practices as negentropic expenditure of energy: maintaining symbolic

order against the second law of thermodynamics, according to which particle movements tends towards equal dissipation *alias* disorder

- culture technical in its sense of standardization and ritualization, but only with the escapement-controlled wheeled clock did media time emerge in a well-defined sense. Even if ritual and ceremony already represented a form of temporal regularity and performance, those instructions were still like handwriting in comparison to typography / machine writing: variable in their concrete theatrical manifestations; in the working world of modernity, "ritual is replaced by the precise, technical operation" = Ernst Jünger, *Über den Schmerz*, in: *Blätter und Steine* [orig. 1934], 2nd ed. Hamburg (Hanseat. Verlagsanstalt) 1941, 208

- technological *routine* ("path of habit") denotes a "fragmenting of work into simpler motor functions that can slowly be combined" = Hugo Münsterberg, *Grundzüge der Psychotechnik*, Leipzig (Barth) 1914, 559; in discrete, digital systems "[a]ny step is [. . .] as important as the whole result" = John von Neumann, *General and Logical Theory of Automata*, in: idem, *Collected Works*, Vol. V: *Design of Computers, Theory of Automata and Numerical Analysis*, ed., A. H. Taub, Oxford (Pergamon Press) 1951, 292

- escapement-controlled timepiece much more than a trivial mechanism but a cybernetic, that is: feedback-regulated system; in order to understand its isolation / autonomy from its human setting requires forgetting that it was made in the first place in response to specific human needs = J. D. North, *Monasticism and the First Mechanical Clocks*, in J. T. Fraser and N. Lawrence, eds. *The Study of Time II. Proceedings of the Second Conference of the International Society for the Study of Time*, Berlin / Heidelberg / New York (Springer) 1975, 381; once such a mechanical clock is put to work, its functions depend on a genuinely media-governed logic, indifferent to whether it is being applied in a medieval monastery or in a present-day museum; message of this media mechanism is not only the acoustic signal that human ears decode as an indicator of temporal measurement, rather a media-physical reminder of frequencies and oscillations, rhythm and repetition as basic media-archaeological ingredients

- innovative media-epistemological feature of the mechanical clock, the coming into being of the mechanical escapement in the thirteenth century, as much bound to moments of cultural history as to techno-logical laws operating in an ahistorical temporal register, and its "tradition" is as much a function of the survival of knowledge about wheel-driven clocks (astrolabes) from antiquity into medieval times as it is part of a techno-logical self-reference that is only partly identical with the discursive variations of human history

- verge-and-foiot escapement = decisive mechanism that distinguished the "truly mechanical clock" from traditional astronomical mechanisms; *later* (or functionally) re-/displaced by the pendulum. Periods of swing (oscillations) been part of cultural knowledge but restricted to the observation of planetary systems for agricultural use, became fundamental parameter in the measurement of micro-temporal events; insights of media-operative measuring opened up a world of time-critical operations hitherto unknown to human perception (in the original sense of *aisthesis*). Media archaeology does not

aspire to explain the ways in which the oscillatory mechanism used for both measuring time and striking a bell in the thirteenth century were absorbed into cultural discourse such as the high ritual of the church. The canonical hours of the monastic life—especially according to the Cisterian rules (such as Rule XCIV, which referred both to *horologium temperare* and *facere sonare*) — almost inevitably engendered the demand for some sort of automatic control. With clockwork, control was given over to the time of automata. But the driving energy behind the development of the mechanical clock—the desire to cause a clock to sound on its own—operates on a level that is not restricted to religion. Parallel to the unfolding of cultural logic, something else is at work. Media archaeology pays attention to what was established on a subconscious level prior to culture and religion: the training of a sensibility to micro-temporal events

The Anachronism of the Ticking, Wheeled Clock

- chronological origin of the time-giving mechanical escapement-driven clockwork itself literally "escaping" historical narrative: "No entry in a chronicle, no narrative account, no description of the construction makes the invention an event we can date or locate" = Dohrn-van Rossum 1996: 46; early weight-driven clock in Cathedral of Strasbourg, built by Henri de Vick (Wieck) between 1362 and 1370. Around 1320, Dante Alighieri describes in the *Divine Comedy* a wheeled clock with a mechanical escapement. Notwithstanding such references, invention of the verge-and-foliot escapement-driven clock belongs to what Sigfried Giedion describes as anonymous history = Siegfried Giedion, *Mechanization Takes Command*, Oxford (Oxford University Press) 1948. Although an astronomical clock furnished with a kind of escapement mechanism had already been introduced into China in the year 1092, Gerhard Dohrn-van Rossum considers the foliot escapement as "in all likelihood an independent European development" = Dohrn-van Rossum 1996: 105; strictly media-archaeological argument. Chinese clock contained an escapement made by pivoting: "balance levers that stabilized a stop-and-go motion. The principle of the European escapement, which employs the centrifugal force of an oscillating inert mass, does not resemble it in any way whatsoever" = van Rossum 1996: 87. Only on a technically close reading does this difference come into view. As Joseph Needham writes, "We cannot rule out the possibility of completely and independently parallel lines of thought occurring in widely separated parts of the world" = Joseph Needham, *The Shorter Science and Civilisation in China*, vol. 1, ed. Colin A. Ronan (Cambridge: Cambridge University Press, 1978), 58. Therefore another temporal order, one that reacts asymmetrically to the temporal economy of telling the "origin" of the escapement as a moment precisely registered in historiography; media archaeology refers more to the discrete time of machines as to the symbolic time of human culture called "history". The digital beat of clockworks and the discrete series of letters in archival records are different kinds of non-narrative temporal information.

- wheeled astronomical clock at St. Mary's Church in the city of Rostock still ticking today; has been preserved in its original form and is fully functional since 1472, with parts of its mechanics incorporating a precursor clock from 1379; Manfred Schukowski, *Die astronomische Uhr der St.-Marien-Kirche zu*

Rostock, Rostock (no publisher indicated, brochure) 2004, 4. The constant ticking of this clock questions the (self-)temporality of such chronomedical systems: a kind of media time that escapes the discourse of history. Media archaeology involves an effort to capture this media-inherent microcosm of time.

- instead of three times past, present, and future, "it might be fitly said, 'There are three times; a present of things past, a present of things present, and a present of things future'" = St. Augustine, *The Confessions of St. Augustine*, Bishop of Hippo, Book XI, Chapter XX, trans. and annot. J. G. Pilkington, Edinburgh) (T. & T. Clark), 1876, 306; thereby implicit the condition of an intact clock. Among the peculiarities of technical media is the fact that they behave negentropically toward the flow of time. Technical media reveal their essence only by occurring in the present. All *arché*, all origin, is dissolved in this taking place; historicist notion of the "Middle Ages" dissolve into the tick of the wheeled clock as it takes place today

- escapement-driven wheeled clock the opposite of a mnemonic medium: its stored energy (the wound-up metal spring) is a physical-energetic memory, intermittently converted into information (time designation) and comparable to the electromagnetic relay used in binary digital memory. Technological time and historical time differ fundamentally. Commenting on paragraph 80 of Martin Heidegger's *Being and Time* (1927), the chapter concerning clocks, Friedrich Kittler notes that Heidegger did not haphazardly switch from a fundamental-ontological description to a positivistic, cultural-historical description. According to Kittler, Heidegger's dilemma was this: "A history, which is essentially time, intersects with another history, through which the machines of time-measurement themselves pass. Clocks are ontic devices, thus subordinated to fundamental ontology, which nevertheless bring about historically different ontologies" = Friedrich Kittler, *Eine Kulturgeschichte der Kulturwissenschaft*, Munich (Fink) 2000, 235 f.

Hindrance time

- abstract, quantitative time of watches and clocks took over the regime of qualitative religious time; "homogeneous and desacralized time" (Henri Lefebvre), culminating in chronophotography, the technical measurement of the smallest temporal units in working processes in order to optimize production" = Henri Lefebvre, *Rhythmanalysis: Space, Time, and Everyday Life*, London / New York (Continuum) 2004, 73; replacement of metaphysics of a continuous time by a model of discrete pulsing represents not only a culturally historic but also an epistemological shift. In Occident, time of clocks literally introduced bit by bit, with this phrase being more than just a wordplay

- What appears on the "analogue" clock face as a smooth temporal progression (unless indicated by second index) dissolves into "digital" machine counting from a media-archaeological perspective; metonymically, the view of the clockwork itself. In Heidegger's words: "Time is not. There is, It gives time. The giving that gives time is determined by denying and withholding nearness" = Martin Heidegger, *Time and Being*, in: idem., *On Time and Being*, trans. Joan Stambaugh (Chicago: University of Chicago Press, 2002), 16

- infinite or negligible impedance between the two poles of a switch technically called *hindrance*. Its mechanical precursor is the escapement. Through the functioning of the escapement, time counts in binary form. What alphabetic writing accomplished for the phonetic stream of speech, the wheeled clock achieved for time: a radical individuation, a core of occidental combinatory rationality. Ultimately, the sampling practice of signal engineering is at hand, in which individuation means the replacement of an infinity of consecutive values with a finite number of values; Claude Cadoz, *Les réalités virtuelles* (Paris: Flammarion, 1994), 85. Such a quantification of values changes its temporal essence: "Between 0 and 1 there is no time. . . . It is the hindrance that gives the 'discretized' [*diskretisierte*] time" = Bernhard Siegert, *Passage des Digitalen. Zeichenpraktiken der neuzeitlichen Wissenschaften 1500-1900*, Berlin (Brinkmann & Bose) 2003, 9; also Claude Elwood Shannon, *A Symbolic Analysis of Relay and Switching Circuits*, in: *Transactions American Institute of Electrical Engineers* vol. 57 (1938), 713-23; tick of the clock that originated in the monastic order returns in the time-discrete formation of digital computing. In the guiding principle of the so-called von Neumann-architecture for computers, commonly in use today, this sense of time is still operative. "One thing at a time, down to the last bit!" = William Aspray and Arthur Burks, *Computer Architecture and Logical Design*, in: William Aspray / Arthur Burks (eds.), *Papers of John von Neumann on Computing and Computer Theory*, Cambridge, Mass. (MIT Press) 1987, 5 f.

NOTES ON WRITING (THE PAST) COMPUTATIONALLY

Discrete methods: Writing the past retro-actively

- radical media archaeology a non-historicist investigation into technologies from the present past; by-passing contextual information about past media, but close reading getting into contact with technological media in their radical operability and temporality itself. Media archaeological as research method restrains from interpretative approach in history of technology but shares the techno-mathematical situation of media machines in their non-historical presentness. Their functioning operations are the media archaeological moment that is at its core un-historical; see Jussi Parikka, <http://mediacartographies.blogspot.com>

- occasional / event-driven technologies; dynamic media archaeography as it happens in the stored-program computer (von Neumann), in synchronous layers, describes techno-logical recursions, dis- and replacements (McLuhan's "tetrads")

- "Freudian concept of 'retroaction' (in French "après coup"; from German "Nachträglichkeit"); Digital Retroaction: A Research Symposium (The Digital Cultures Project), UC Santa Barbara, September 17-19, 2004; "retroactively" the operations of digital data processing in the present redefining understanding of cultural engineering in the past

- in digital data circuits, "retro-action" not a translation between the past and the present any more, but a cybernetically closed circuit (the feedback-option /

back channel). When we load a document, it does not come from a material, but just logically separated "storage" space (the von-Neumann architecture of computing merges programs and the data to be processed dynamically into the same working memory); computers "retro-actively" transforming narrative aesthetics into non-discursive configuration of events - a formal, algorithmic chronography

- digital media today transforming the present immediately into past ("antiquity", according to Walter Benjamin) by the very speed technological formats and data themselves pass by; "media archaeology of the present" leads to a different perception; past suddenly turns out to be storage - a digital retroaction. Since the tradition of the past suddenly looks like "a medium, in which past ideas and meaning is present in a coded form" = Ulrich Veit et al., *Spuren und Botschaften. Interpretationen materieller Kultur*, Münster / New York 2003, 11; be it material artefacts or records. As long as a culture stores its knowledge in pyramids or DVDs, archaeology as technology of revelation will be practices but might become redundant in a culture which switches from the mode of storage to permanent transfer

- electronic computing where electronic circuits perform logical operations; technical term for this is "inductive retroaction" (flip-flop, designed by Eccles / Jordan 1919). The digital computer operates in terms of numbers represented by simple pulses (a reverse interrelation between physics and representation). Information, numerical *or otherwise*, is represented by means of distinguishable (discrete) characters

Er/zählen: narrative versus calculation

- "Cohesive but Not Coherent: Music Videos, Narrative, and Culture" = paper presented at the 1988 Popular Culture Association Conference by Steve Jones, "schematized narrative as mimetic, analog, and digital, specifying that in digital narrative, a nonlinear 'mosaic of fragments', 'information is presented in discrete steps, bearing no resemblance to what it communicates.' [...] texts whose form stresses discrete digital moments [...] and those whose subject matter is the representation of our increasingly digital culture [...] with digitalization, information becomes easily edited into different forms" = Brooks Landon, *Not what it used to be: The overloading of memory in digital narrative*, in: George Slusser / Tom Shippey (Hg.), *Fiction 2000: Cyberpunk and the future of narrative*, Athens, Georgia (Univ. of Georgia Press) 1992, 153-167, note 2

- Alan Turing's notion of a computing mechanism to calculate computable (real) numbers based on the unconditional assumption that this machine can only exist in discrete "states"

- nondiscursive, algorithmic configuration of events; operation of the machine itself with no discursive agenda, or agency, other than to execute a specific task of functionality

- writing itself not derived as means of communication, but of calculation - with the proto-Sumerian counting "tokens", truly digital. "Counting by numbers": Media archaeology stratigraphically dis/covers a layer in cultural sedimentation

which is neither purely human nor purely technological, but literally inbetween (cultural techniques): symbolic operations which turn the human into a machine as well as they can be performed by machines (once that numbers were abstracted from the material things and could then be re-implemented in matter again, as "calculi" - stones included in a clay cube, sealed, with their written on it) or in computer hardware = Denise Schmandt-Besserat, *Before Writing. From Counting to Cuneiform*. Austin, Texas 1992

- every detail regarding physical tone, colour, shape and movement, after A/D sampling, expressed as quantified rows of binary numbers; this world view conceptually resembling that of Pythagoras, creating a media archaeological short circuit between ancient Greece and the present digital reality, but difference in the micro-physical knowledge (Fourier-analysis) of the vibrational event; "time" dimension mastered by transforming it into the frequency domain

- while Pythagoras saw integer ratios embedded nature (like Leibniz' "deus calculans"), computer literally numbers the world; Leibniz' speculation on the possibility of an eternal recurrence of things, *Apokatastasis panton*. „The alphabet encompasses the world“ writes the German Brockhaus Encyclopedia; more strictly, the alphabet only registers what can be addressed by symbols. Leibniz' literary fragment *Apokatastasis panton* culminates in the option for an imaginary library in which whatever has happened in human past could be shelved - by consequentially performing all possible combinations of letters.

- "The power of repeating the cards [...] reduces to an immense extent the number of cards required", Ada Lovelace comments in her "Note F" (Lovelace, in: Bowden 1971: 395), and hereby describes the power of recursive loops in algorithmic operations: "It is obvious that this mechanical improvement is especially applicable wherever cycles occur in the mathematical operations, and that, in preparing data for calculations by the engine, it is desirable to arrange the order and combination of these processes with a view to obtain them as much as possible symmetrically and in cycles" = *ibid.*; von-Neumann architecture of stored-program computing actually allowing for self-modifying (input-adaptive) calculations in realtime

- task looks immense but is finite - as long as the alphabet is a finite one. Only whatever has been recorded in symbols can return by this play of alphabet = Ulrike Steierwald, *Wissen und System: zu Gottfried Wilhelm Leibniz' Theorie einer Universalbibliothek*, Cologne (Greven) 1995, 65; 23 Latin letters once saluted by Lucretius as elements of an unlimited combinatorics of thought = *De rerum nat.* 1. 823-827; Leibniz' effort to *calculate* a virtual protocol of the world epistemologically still refers to the genre of Annals and Chronicles "by which everything that can be told can be found" = Leibniz to Herzog Johann Friedrich von Braunschweig-Lüneburg, ca. 1671; Hans Blumenberg, *Die Lesbarkeit der Welt* [*1983], 3rd ed. Frankfurt/M. 1993, 121-149 (128 ff.), on Leibniz' speculative *Apokatastasis* (fragment 1715); alphabet the *type-writer* of narrative - the condition which governs what can be told at all - "everything between past and alphabet" (John Cage); whatever cannot be registered in discrete letters will escape memory: „semper enim forent discrimina etsi imperceptibilia et quae nullis libris describi possint" = Gottfried Wilhelm Leibniz, *Apokatastasis panton*, published in: Max Ettliger, *Leibniz als Geschichtsphilosoph*, München 1921, 31; Leibniz even reducing this digital

alphabet to two (binary) symbols only: "Wonderful origin of all numbers from 1 and 0, which provides an image of the secret of creation, since everything stems from God and otherwise from nothing: *Essentiae Rerum sunt sicut Numeri*" = Letter by Leibniz, 18 May 1696, quoted after: Hans J. Zacher, *Die Hauptschriften zur Dyadik von G. W. Leibniz. Ein Beitrag zur Geschichte des binären Zahlensystems*, Frankfurt / M. (Klostermann) 1973, 209

- discrete processing at odds with continuous recording; can continuity be calculated. Once energy is turned into electricity (our physical basis of information processing), we already move within a discrete universe, since electricity is not a coherent, continually disseminating flow or fluid, but rather composed of discrete elements = Laszlo von Szalay, *Moderne Technik. Elektrotechnik*, Berlin (Safari) 1954, 386; natural language made up of discrete, finite elements (phonemes) so that all descriptions of continuous processes happen by a finite discrete sequence of finite elements = Pattee 1974: 130; Leibniz offering a solution by his differential and integral calculation: "A continuous dynamical system, such as the motion of several mass points in a potential field, can be calculated in practice by approximating the values of the continuous variables over a discrete mesh, and representing the mesh behavior by an automaton."

- "data" derived from whatever can be measured and thus recorded. Remains what is being filtered out by digital registration - imperceptible differences which are not being remarked by human senses (aesthetically) and electronic sensors (CCD chip)

- media archaeology dealing with the new possibilities of "petites perceptions" (Leibniz), i. e. the subliminal operations (of nerves: von Helmholtz) as well; Shannon-Nyquist interpolation theorem, the media/anthropological interface between what humans (aesthetics) and machines (media-aesthetics) processually perceive. René Descartes referred to the slow growing of tree day by day: Who has ever noticed the little elements operating to make this tree grow? Such elements are so small and slow that they cannot be remarked naturally. But digital culture nowadays privileges an over-sampled reading of such processes

- once pixelated, that is: digitally coded, an image losing all continuous information, that is: information "inbetween"; a digital image of a pebble beach can easily be compressed, that is: calculated. Latin *calculatio* is derived from *calculi* themselves, that is: counting with pebbles in the sand; at the limit of digital computing: although a micro-ship materially built on sand (silicium), it is not able to calculate the random distribution of sand without aliasing effects; a human image drawn into the sand at the seashore will (an allegory designed by Foucault) vanish in specific waves in ways no digital computer will ever be able to emulate (except quantum computing); after a while, will rather look like the jammed images in early analogue TV

Computer games and / or narrative

- new media "literacy": bits which the *turingmachine* reads and (re-)writes

- Jesper Juul, Games telling Stories? in: Games Studies (2001), 7: games not narrative, but configurative; cp. TM "m-configurations" = Turing 1936
- games double-rendered, on the time-axis (play) and on the spatial axis (programming)
- computer games time-critical, with short-term moves and short-term neurological memory. The message of the medium computer games is not stories, but: cybernetics. Man experiences himself as a cybernetical model when interacting with digital media. In computer games a new concept of time is introduced
- aesthetics of CD-ROM: Programmer not interested in story; jump addresses (to Hot Spots). Designing a Computer Game = 95 % administration (links); 5 % authorship; algorithm replaces story-board
- un/balance between storytelling (plot) and interactivity
- when players enters the scene in *Myst*:, no narrative guide; "story" unfolds only in experimentation; Aaseh, "ergodic" literature
- narrative structures in computer games a function of accelerating hardware, software, graphical resolution, memory capacities

Computers *avant la lettre*? Writing media history as media archaeology

- crucial difference between the "Renaissance computer" logic and technological machine metaphors, and the machine itself that actually in a real physical process handles the data, and not just a symbolic calculation of data; even if the theoretical foundation for the development of the computer was present many centuries before its physical manifestation, there is a substantial difference between regarding the computer and its theoretical foundation solely as a symbolic machine and regarding it as a physical object that actually conducts the calculations in a real physical process
- Neil Rhodes / Jonathan Sawday (eds.), *The Renaissance computer: knowledge technology in the first age of print*, London / New York (Routledge) 2000, Introduction: Paperworlds. Imagining the Renaissance Computer, 1-17
- "Knowledge of automatons, or of clockwork toys, played no part in the story of cinematography, nor is there any link between it and the production of animated 'scenes'. We can therefore omit plays, the baroque automatons, and the marionette theatre. Even the 'deviltries' of Porta, produced with the camera obscura, the phantasmagorias of Robertson, the 'dissolving views' of Child, are not to the point. All these discoveries did not lead to the first genuine moving picture sequence" = C. W. Ceram, *Archaeology of the cinema*, as quoted by Erkki Huhtamo, "From Kaleidoscomaniac to Cybernerd. Towards an Archeology of the Media" = <http://www.debalie.nl/dossierartikel.jsp;jsessionid=7E2098DE44FCDF3B4368D087406665AF?dossierid=10123&articleid=10104>

Digitizing signals from the receding present / recent past

- light and sound signals belonging to the regime of the real, while their digital sampling translating them into the symbolical, that is: countable (accessible for computing) as frequencies. But within sampling, quantization errors occur: the real always returns (Lacan)

- media-archaeological recording primarily memorizing the noise of the wax cylinder itself - technologically, a different kind of information on the real. Media archaeology opens our ears to listen to this as well, not to filter this out (against the "cocktail party effect" of hermeneuticised psycho-acoustics); phonograph as media artefact does not only carry cultural semantic like words and music, but is at the same time a frozen, implicit (en-folded) knowledge of its engineering as well, by its very material fabrication, which- waits to be de-frozen, liquified

- with an analog-to-digital converter, the sampling rate controlling how many samples taken per second / per year (in the case of the St. Gall annals) - all depending of the quantization level. On the time-axis: year 700, 701 and sine wave of events / sampling time; annals as the graphical indication of a conscious quantification, that is: digitalisation of temporal processes - the abstraction of a temporal-successive quality as a geometric, thus static figure, no history at all

- Fourier transformation of a temporal function or sequence of signals into a spectrogram; not historiography any more, dealing with macro-temporal processes, but genuine mediography which deals with temporal micro-events, with time-critical operations

- for each private live hour of an individual, Leibniz calculating 10 000 letters and thereby makes live finitely countable, explicitly annalistic = Leibniz in Ettliger 1921: 29

- according to Norbert Wiener, telegraphic transmission of a human being, if sufficiently describes as information; "streaming" data a metaphorical disguise; see media art installation Jim Campbell, *Church On Fifth Avenue*, 2001: Jim Campbell, *Church on Fifth Ave* (2001): passengers pass through screen, transform from discrete into continuous appearance. Custom electronics; movie: <http://www.jimcampbell.tv>: "A matrix of 32 x 24 (768) pixels made out of red LEDs displaying a pedestrian and auto traffic scene in NY from an off street perspective. There is a sheet of diffusing plexiglass angled in front of the grid. As the pedestrians move from left to right the figures gradually" - continuously, or in discrete steps? - "go from a discrete representation to a continuous one (or metaphorically from a digital representation to an analog one)." But even the impression of continuous movement, in digital projection, is always already discrete; see the artefacts at margins of the Campbell installation QuickTime Movie. The analoge becomes a nostalgic re-entry

- dis-affectation; media-archaeological gaze adequate to machine aesthetics itself which is implanted into the human *mind* (like Turing could imagine the

human as "paper machine"

Archaeology, Computing

- the very term "memory" for permanent (ROM) and ephemeral (RAM) data storage in early digital computing; instructions like "Memory" in the text saving menus of computer software a semantic archaism; difference between procedural presence and storage of data is a function of directing codes; during the the second Gulf War both missiles and news (about missiles) were in principle transmitted by similar (or same) electronic rays

- memory not linked to the past but rather radically present; mathematically informed archaeology practicing *cluster analysis*; historiographic concepts of past times nothing but a narrative disguise of material entropy, the final equilibrium into which accumulation transforms. *Cluster analysis* is a non-discursive statistical technique, the true memory of waste; computer disposes of a better memory of waste *to count on*; only its calculating operations are able to make sense out of apparent disorder

- computational *imagineering* as metonymic transformation of non-intuitive data into graphics; *technológos* "collecting" (*legein*) fragments into shapes: Thomas Quarry announcing it in an advertising for IBM from Casablanca where Jean-Jacques Hublin unearthed a few fossilized skull fragments. Hublin and a team of IBM scientists "fed this shattered jigsaw puzzle into a unique program called Visualization Data Explorer. The tiny pieces helped form an electronic reconstruction of our early ancestor, the first Homo sapiens. This new IBM technology has turned time back 400.000 years, uncovering clues to the origins of mankind" = in: *Wired* 3.03, March 1995

- Sphinx sculpture in front of the Cheops pyramid restored by aid of computer in detail; Mark Lehner of the Oriental Studies Institute (University of Chicago in Illinois) has overlapped photographs of the sphinx with portraits of pharae statues and by photogrammetric composite pictures reconstructed the most probable archetype of the sphinx which might bear the features of pharae Chefren (4th dynasty) = *Frankfurter Allgemeine Zeitung* from 15th July 1992

- project undertaken by the Parisean École Française d'Extrême Orient, dealing with the reconstruction of the nine hundred years-old ancient Baphuon temple of Angkor in Kambolia; 500 000 stones, scattered around the ruin, to be restored to their previous placement. An infographics company provides three-dimensional photographs as computer modelling of the temple, serving as conceptual grid to insert the fragment into = "Steine mit dem Computer sortieren", in: *Frankfurter Allgemeine Zeitung* of 12th April 1995; computer providing a better memory of waste than historical, that is: human imagination can cope with

NOTES ON RE-ENACTMENT: COMPUTING IN / AS NON-HISTORICAL TIME

The operative presence of technological artefacts from the past

- media archaeological focus on the *operative being* of technological artefacts; only here that artistic materialities deserve to be called *medium* in the sense of information engineering; Paddy Scannell's book *Television and the Meaning of Life* (Cambridge 2014) is an up-date of Heidegger's philosophy of artefactual tempor(e)ality. Heidegger's ontological distinction between beings (things) and their being. The use of the hammer; only in its accidental failing the tool becomes apparent as such: Heidegger 1927/1962: 98; *vorhanden* is the distant observation / measuring of the object; *zuhanden* is its "handy" use: "I know what a hammer is by using it properly" = Scannell 2014: 60, hammering is *operative* ontology - a "thing-for-use"; technological configurations are *media* only when being in operation; Scannell 2014: chap. 5 "Turning on the TV set", 60-77

- ancient electro-magnetic telegraphy relay; to what degree "digital" communication not only comes after but actually preceded the time of analog telephony and radio

Davis (2000) observes the particular importance of the electromechanical relay (with its two "binary states" open and closed):

It was only with the development, beginning in the 1930s, of electromechanical calculators using electrical relays, that machines were built having the scope Babbage had envisioned."[80] = <https://en.wikipedia.org/wiki/Algorithm>, accessed January 16, 2019

- time-based character of both theatre / drama and the von-Neumann-computer architecture which links both; transform this into experimental performances which (re-)translates the sublime data processing in machines (otherwise unrecognizable for slow human senses) into three-dimensional, audio-visual space

- "antique" technological items not primarily objects from the past; they require presentation (and re-presencing) as "time objects" (Edmund Husserl), not as frozen pieces of hardware to be stored in shelves; focus the visitors' attention towards the inside and the function of the objects; "open source" and "open access" meant literally here, with a hands-on bias

- early computer game cassette tape identical with audio cassettes familiar from popular music industry in the 1980s. Only when operated in combination with an early home computer it reveals its meaning as binary data storage for a video game.

- ancient Wire Recorder appearing like the dead end of a technological artefact. But when restored to operation, all of the sudden the recording of oral poetry from the early 1950s (see Albert Lord, *The Singer of Tales*) or vocal testimony from post-World-War II refugee camps (see Boder, *I did not interview the dead*) might resound from the wire spool.

- magnetic core memory grids essential in early electronic computing to keep data for storage in a non-volatile way. It takes operative analysis to decode this message. Such an artefact may be read out data-forensically to reveal its latent information after 40 years; delayed memory of such kind not historical but embodies a different kind of tempor(e)ality

- different from other archival records, technological diagram not historically distant but allows for re-generative experience of a past as presence - such as a musical tone or electrified voice; fig.: Alexander Graham Bell's circuit diagram for a tune fork telephone
- in terms of historical research, meaning of a past material object in the information attached to it in the form of associated textual records = David Crowther, *Archaeology, Material Culture and Museums*, in: Susan M. Pearce (ed.), *Museum Studies in Material Culture*, London 1988, 35-46 (esp. 42); media archaeology dealing with objects which can be reenacted by virtue of their own inherent techno-logics, momentarily un-doing the "cultural history" gap
- re-enactment of "obsolete" electronic circuitry by operative diagrammatic reasoning; techno-mathematical ratio electronically unfolding again as arche- or genotype, not simply historically distant. In electro-acoustics, harmonic oscillations, by virtue of the medium specificity of mechanical or electro-magnetic vibrations, still behave the same; the present can share the original experience
- Heinrich Hertz' late 19th century experimental setting of wireless "radio" spark transmission in the lecture room of Karlsruhe Technical University; can still be rehearsed and still behaves the same. Media operativity allows for time-tunnelling which is well known from human experimental archaeology; all the difference is the active agency when it comes to *media* archaeological artefacts
- escapement-driven mechanical clocks since late medieval times though liberated oscillations from the impulse of the human hand; electric circuitry since nineteenth century enabled the resonant circuit which is essential for generating non-material oscillations and for receiving electro-magnetic waves.

Re-enacting logical machines

- Heidegger, "Altertümer im Museum". "An artifact is something that happened in the past, but, unlike other historical events, it continues to exist in our own time. Artifacts constitute the only class of historical events, that occurred in the past but survive into the present. They can be re-experienced: they are authentic, primary, historical material available for first-hand study. Artifacts are historical evidence" = Jules David Prown, *The Truth of Material Culture: History or Fiction*, in: Steven Lubar / W. David Kingery (eds.), *History from Things. Essays on Material Culture*, Washington / London (Smithsonian Institution Press) 1993, 3 - though rather media-archaeological than "historical", since historical discourse is bound to textual, narrative historiography. Against a "textual" reading of artifacts, a material techno-logical configuration is non-discursive, non-narrative
- "Reverse engineering of past techniques provides a way to 'fill in the gaps' in the text. It can also substitute for the text when 'technological processes cannot be adequately described with words [...]' = xxx, *Reconstructions, Historical and Otherwise*, in: xxx

- digital photography ideally (if not practically) "eternal; it is not subject to entropy, to the second principle of thermodynamics" = Vilém Flusser, *The Photograph as Post-Industrial Object. An Essay on the Ontological Standing of Photographs*, in: *Leonardo* 19 (4), 329–332 (331). But "[a]lthough digital information is theoretically invulnerable to the ravages of time, the physical media on which it is stored are far from eternal" = Jeff Rothenberg, *Ensuring the Longevity of Digital Documents*, in: *Scientific American*, Vol. 272, No. 1 (January 1995), 42-47 (42)

- computational media definition not primarily the technology but formats; former technical media like television or radio or the book become formats to be perceived on the computer screen; behind them is the software which defines these objects and enables old media to re-entry the digital sphere; underlying software therefore a cultural document of our time, but how to a) preserve software, b) how does museology put software on display?

- source-code based media art as software "eternal" in the techno-*logical* (Platonic) sense: "Software does not wear out or break down in the traditional sense. Once a software-based system is working, it *should* work forever (or at least until the underlying hardware breaks down [...]). Any latent 'bugs' subsequently revealed in the system are considered flaws in the original design or implementation [...]" = Nathan Ensmenger, *Software as History Embodied*, Editorial in: *IEEE Annals of the History of Computing* (2009), 86 and 88 (88)

- to what extent the archival record (document) depending on its material medium (monumentality); symbolical code can be transmitted (now "migrated") with a high degree of fidelity in copying, regardless the material support. Thus the symbolic code (like the genetic code), esp. in the alphabet, is mostly invariant towards historical, i. e. entropical time. Digital *bits*, as informational units, *per definitionem* (Norbert Wiener) are neither matter nor energy dependent = Rudolf Gschwind / Lukas Rotenthaler (interviewed by Ute Holl), *Migration der Daten, Analyse der Bilder, Persistente Archive*, in: *Zeitschrift für Medienwissenschaft* vol. 2, no. 1 (2010), 103-111 (104)

- "The quality of the medium is of secondary importance, as long as the 'code' can still be decoded" = Rudolf Gschwind, *Digitisation and Long Term Archival of Digital Data*, in: Lioba Reddeker (ed.), *Gegenwart dokumentieren / Archiving the Present*, Vienna (Eigenverlag basis wien) 2006, 183-195 (185); results a rather ahistoric form of tradition, different from the scratchy audio signal as phonographic record or the "stealthy disintegration due to the relatively low stability of photographic material" = Gschwind 2006: 183

- documentary science, notion of "logical preservation" = Hans-Joergen Marker, *Data Conservation at a Traditional Data Archive*, in: Edward Higgs (ed.), *History and Electronic Artefacts*, Oxford (Clarendon Press) 1998, 294-303 (296); any information grounded (material *arché*) in or on a material support (storage medium), which introduces another, different tempor(e)ality: entropy. "*Prentice Hall's Illustrated Dictionary of Computing* (Nader 1992: 412) irreversibly severs the material link by noting that 'software is independent of the carrier used for transport'" = Doron Swade, *Preserving Software in an Object-Centered Culture*, in: Higgs (ed.) 1998: 195-206 (195); metonymy which takes the Floppy Disc as a material support for the software itself a hint to the material link. If past

information is not just symbolically emulated but simulated, its temporal (entropic) behavior must be archived as well - like the scratch, the noise of an ancient Edison phonographic cylinder when being digitized. One method is known from computing as physical modelling.

- epistemological difference between material degradation to the new phenomenon of obsolescence of multi-media data formats; well-known danger to cultural goods, physical entropy, in the logical sphere replaced by a flat tempo(e)ality which is rather a logical state than a temporal ("thermic") object

Emulation: between ahistoric algorithm and its entropic implementation

- not only that algorithmic thinking has an impact on architecture; media-archaeological perspective rather from within: the "architecture" of implemented algorithms itself

- "algorithm" in the context of computing (instead of abstract computation) not logo-centristically reducible to the written code lines (like a musical "score") but techno-logically implemented in the hardware, as *executable* program, in computing architecture. In itself, an algorithm just a mathematical notation which enacts nothing by itself. It has to be *read* by (human or nonhuman) machines (the Turing machine "tape reader"); better not limited by capacity-limited human eyes. It has to be implemented into physical matter (the "computer" as artifact) in order to be *effectively* gifted with time-critical operativity, to become processual

- operative media preservation of early digital works in architectural design linked with the challenge of re-enacting its (techno-)logical machines; ahistoricity of / in computer architecture. How to exhibit computational machines? Doron Swade, as curator of the computer department at the London Science museum, pointed out this challenge for curators. "It's very complex to preserve software on the original hardware; the new option is to emulate the former computer architecture itself as software in order to display its programs (be it computer games, or dynamic media art). It has to do something and then you need again the running system to operate this software" = Swade 1998: 195

- an algorithm surviving its actual electronic implementation; techno-archival "two bodies" (Kantorowicz) the tectonics of computer hardware (in its von-Neumann architecture), *and* its algorithmic codes

The ahistoricity of computer architecture

- digital computer essentially a "paper machine" (Turing 1937); possibility to disentangle code from the hardware needed to process it, just as, with musical scores or literature, the performance of playing or reading re-enacts the symbolic instructions. Is the a-historicity of performed code, or of performed music, coherent with the a-historicity Ricoeur sees in the written text when it is actualised through the performative act of reading? Computation is logical and

mathematic in essence, so when a new computer emulates an old computer's video game, it actually functionally embodies that old computer during the actualization process. Still it is far slower or faster than the obsolescence-driven hardware that originally supported their existence; preservation should not concentrate on the code only (the "literary" work) whose instructions are perhaps the only time-resisting matter of computer art's "two bodies". Some programming languages may become more obscure than others, but an instruction book on a programming language is also symbolic based, hence time-resistant, work. In Washington, the Library of Congress early movies *paper print* archive preserves early films that can now be restituted, re-enacted, re-animated - like information from the optical images of flat digital fossils like an early RAM where bits are indicated by colour. Much of what will be preserved in terms of computer culture from the on-going decades will be actually patent-related (thus "archival"), rolls of code printed on paper for copyright purposes still in libraries, hundreds of years after the electro-magnetic supports on which they were created are lost; task of a library or archive, in art museums: physically located bitstream on the storage medium must be preserved as *raw images* for future analysis = Thorsten Ries, Die Geräte klüger als Ihre Besitzer. Philologische Durchblicke hinter die Schreibszenen des Graphical User Interface, in: Editio 24/2010, 149–199 (155)

How to exhibit computational machines?

- software, considered as cultural artefact, not a material object any more, rather an executable file which unfolds only when being processed (a truly processual time-object). This pushes the possibilities of museum display to its limits. A computer as hardware can be traditionally displayed as an immobile object, but its time-critical and „bit-critical“ processes are never in *stasis*, just like frequency-based acoustics (sonic evidence in museums) needs performance in time to take place. With the electronic image, this extends even to visual evidence
- time-criticality a feature of media-archaeological analysis which does not simply media-philologically read source code but focuses on the (f)actually (technomathematically) implemented algorithms
- "What does 'break' over time is the larger context of use" = Swade 1998: 195, its adaption to new needs, its implementation into the historical context. "Coded electric pulses is very immaterial, you can not touch software as such. This is a big challenge for the traditional object/artefact orientated museum" = *ibid.*
- past design for a media (art) piece time-delayed being realized in the present. Charles Babbage's detailed circuit diagram of Difference Engine no. 2 remained unrealized since 1849, as a paper machine, in latency, as Babbage commented: "The drawings are nearly finished, and the mechanical notation of the whole, recording every motion of which it is susceptible, is completed" = quoted after Bowden (ed.) 1971: 342 (Appendix); Babbage himself designing a "symbolic notation for his calculating machines which could be diagrammatically "run" (tested): a kind of crude emulation, known from cybernetics (block diagram of feedback systems). This concept of diagrammatic timing allows for the transmission within the time channel as well. On occasion of Babbage's

200th birthday in 1991, at least the arithmetische unit has been belatedly constructed in the London Science Museum - "a modern original of an old design", writes Doron Swade, the then curator of the Computer Department" = Doron Swade, *Virtual Objects - Threat or Salvation?*, in: S. Lindquist / M. Hedin / U. Larsson (eds.), *Museums of Modern Science*, Canton, Mass. (Science History Publications) 2000, 139-147 (142). "Capturing the operational persona of an early machines on a latter machine" = Swade 1992: 209 allows to unfold potentialities which were not even realized in the original machine - which is the essential bias of retro-computing ("past-in-the-future").

- logical machines, unlike energetic machines, less dependent on historical time: "Logical simulation as a virtual object in some respects survives the forensic test of historical utility" = Swade 2000: 146

- techno-logical piece inherited from the past becoming a piece of *futurum exactum*: "The logical replica embodies an inexhaustible set of predicates and can be interrogated in the light of unforeseen enquiry in ways that physical replica cannot" = Swade 2000: 144; Klaus Wohlfarth, *Zur Rekonstruktion der Z3*, in: *Wissenschaftliches Jahrbuch 1992/93*, Deutsches Museum München 1993, 205 ff.; ahistoric hermeneutics of the machine (since the diagram transcends the boundaries of the historical context); Swade referring to the Turing machine concept itself. Different from other high-technological media, "Turing [...] argued that what defined a computer was not the medium of its physical implementation but the logical rules that define it", and "[...] the identity of a computer is not exclusive to its physical hardware, which may be regarded as accidental to existence but is at least partly, if not wholly, owned by the logical rules that define its operation" = Swade 2000: 146

- different from an "action" painting by Pollock, a piece of computer art not uniquely bound to its actual physical implementation. When the core operation of computational art is algorithmic, the source code is the "virtual" body of the actual embodiment - a dynamic variance of the Elisabethan political fiction of "the king's two bodies" (Kantorowicz)

- physical and logical laws of material media suspended from relativistic cultural historicism. At the same time, techno-logical knowledge has to be materially implemented as "hardware" in order to become media-active; this implementation embeds the process in a temporal context with its proper "historical index" (Walter Benjamin).

- in media archaeological terms, radically different preservation strategies for electronic art and computer art. Both have "two bodies": the electro-physical one, and the circuit design / logical block diagram. Contrary to analog electronic devices like radio and video, the computer is essentially logic, therefore the preservation of the logical design is mandatory, while for analog electronics such as video art, signal processing is a direct function of its hardware

- while museum of cultural and technological history successfully presenting a mechanical object such as an early telescope, even if it is broken and mutilated, software collections "imply a functionally intact copy with the promise or potential of running it" = Doron Swade, *Collecting Software*:

Preserving Information in an Object-Centred Culture, in: History and Computing, vol. 4 No 3 (1992), 206-210 (208), to fulfill its "enunciative function" (a term from Foucault's *Archaeology of Knowledge*) since software belongs to propositional logics itself; "mode of existence" (Gilbert Simondon) of computational algorithms necessarily unfolds in its operational vectors only. Functional intactness in *archived* program software (only the archive or the archive-library ensures the possibility for unforeseen future enquiries - which is the condition to generate newness from old records, that is: *information*) demands the ongoing maintenance of "bit-perfect records" = Swade 1992: 209 and compatibility with the original hardware - unless this is itself emulated in logical (as distinct from physical) replication, that is: became software itself (a *mise-en-abîme*), maintaining even the original execution times, which is: the *aura* of implemented and running software as *time object*. For a future historian, it is not sufficient to just re-create the "feel" of an early computer game; it rather has to be inherently authentic, even on the subliminal level below human perception (the "formal materiality" as defined in Kirschenbaum 2008: 34); emulators "mimic the behaviour of hardware" = Rothenberg 1995: 47 - true co-originary *mimesis* (in a temporal sense beyond "history")

- contextual metadata recorded in unspaced bitstreams; a way to mark the difference in out-reading the data. "Computer scientists call the solution to such a recursive problem a *bootstrap* which provides "some context, which humans can read, that explains how to interpret the digital storage medium" = Rothenberg 1995: 44

- *different* from the familiar material artefact in museums, digital media artefacts in a dialectical synthesis combining what has been separated so far between historical and archaeological sciences: textual code and materiality. Since in its most literal sense techno/ology means first of all logical (mathematical, diagrammatical) knowledge which can be symbolically coded as "software" and thus be transmitted across time almost without loss through re-enactment. Any coding is an act of encryption. The risk is known from Bletchley Park where the British intelligence tried to decipher the German Enigma coding of wireless telegraphy messages: Any encryption makes it difficult (and in time-critical terms) even "impossible to recover the original bit stream without the decryption key" = Rothenberg 1995: 47; has been a cryptographer (Ventris) who finally deciphered Linear B writing from Bronze age Greece

- different from the familiar archaeological artefact, digital documents primarily consisting of a non-material, non-energetic, rather informational (Wiener) essence: a binary, logical object structure, which can be dissociated from the actual material data carrier and can be losslessly copied, transmitted and stored = Thorsten Ries, Die Geräte klüger als Ihre Besitzer. Philologische Durchblicke hinter die Schreibszene des Graphical User Interface, in: Editio 24 (2010), 149–199 (153); computer not simply a mathematization of a material mechanism and thus strictly dependent on a specific apparatus like previous media technologies (the phonograph, electronic television), but in a dramatic epistemological rupture born from mathematical theory (Turing's "universal" symbol-manipulating machine 1936/37), a radical mechanization of mathematics

- in algorithmic coding the task to be performed developed into a time series; in order to be executable, any algorithm has to take place in matter - even if this is just numbers and letters on paper, written and read by humans (the Turing machine)

- so-called Mechanism of Antikythera from late Hellenistic times, even if corroded to an almost entropic mass of metal, still remodelled by Derek de Solla Price; experimental archaeology of material cultural knowledge oscillating between implicit (latent) knowledge in terms of physical and mathematical self-evidence and "tacit knowledge" (Polanyi's undocumented social skills / *techné*)

Operative rather than "dead" media collections

- for techno-epistemological analysis of media art, emphasis not on the phenomenology of user-interaction but on the material artefact, its media-art(e)factuality, encompassing the materiality of both analog and digital media for cultural tradition, and software as new objects of knowledge transmission and as a challenge to museum-like conservation

- imperative for *operative* preservation of media-archaeologically relevant objects (as argued by Peter Donhauser, Technical Museum Vienna, for his operative re-creation of the historic Bechtstein electronic piano, or Doron Swade, when curator of the computing department in the Science Museum, London, on the museological challenge of "preserving software")

- objects whose main function is processuality (both material and algorithmical), as *archive in motion* (Rossaak) requiring a dynamic preservation museology

- methodology of "operationality". If the cultural and discursive knowledge of media is not meant to be limited to images (in texts and books), to distant observation (in museums) and to pure documentation (in archives), there is a need for real places and digital platforms where technical objects can be confronted in their primary materiality and virtual operativity. Analysis here means actually or symbolically opening the "black box" to get insight into what media do. For analog technologies this means actual disassembly; for software-driven media this means to get acquainted with programming languages like Assembly (close to the machine). This means expanding further from representational approaches towards the idea of operationality of the devices in collections. Hence through operationality, the focus of the archival work turns from the normal function of preservation to issues of technological education, theoretical inquiry and artistic practice; counter-strategy to "black boxing" design strategies of modern technical media; expand the usual archival or museum functions concerning cultural heritage of technology and scientific apparatuses

- practices of disassembling and reassembling becoming integrated as part of the activity of the operational media archaeology labs

- technical objects in "media" state / being only when implemented in operation. In a comparison with traditional practices of media-historical display

(with representatives from museums, archives and collections), the specific need for an operative assemblage of technical objects in the context of cultural and academic teaching and research shall be outlined - both for the epoch of analog and of digital media. The specific "triad" of Media Archaeological Fund (the presence of artefacts), Signal Laboratory (digital signal processing), and Media Theatre (machinic-operations confronted to human performance) provides for a model of operative media analysis

The temporal challenge of Internet art

- genuine, medium-specific (and not just content-oriented) Internet art from an error: "In December 1995 Vuk Cosic got a message, sent via anonymous mailer. Because of incompatibility of software, the opened text appeared to be practically unreadable ascii abracadabra. The only fragment of it that made sense looked something like: {...]J8~g#\;Net.Art [...]" = Alexej Shulgin, *Nettime*, quoted in Galloway 2004, motto to chap. 7 "Internet Art"

- Cosic interested in ASCII code during research "on low-tech aesthetics, the economy, ecology and archaeology of the media, on the intersections between text and computer code, on the use of spaces in information, its fluid nature and infinite convertibility. Out of this came [...] Deep ASCII and ASCII History of Moving Images, a history of the cinema converted into text format" = https://en.wikipedia.org/wiki/Vuk_%C4%86osi%C4%87 (accessed January 16, 2017); created File Extinguisher, an online service that allows to delete files with absolute certainty; <http://www.ljudmila.org/~vuk/ascii/film>

- Galloway 2004: 217: the 404 error code, used by artist Lisa Jevbratt's *Non-Site Gallery*. Since 1995, in early explicit *net.art* (including, f. e., Jodi) , the medium is the message - like every first, media-archaeological technologically self-reflexive media art (video), "is concerned primarily with the net/work, while later Internet art [...] has been concerned primarily with software." = Galloway 2004: 218 f. "As computers and network bandwidth improved during the late 1990s, the primary physical reality that governed the aesthetic space of net.art began to fall away" = Galloway 2004: 220; the shift from media-archaeological aesthetics to content.

- Swiss initiative *Aktive Archive* (www.aktivearchive.ch) dedicated to preserving so-called "instabile media", symbolically re-enacting even an online-art work on flash-based dynamics as CD = Vera Kuni, in: Müller / Scheidgen (eds.) 2007, 312; Variable Media Network www.variablemedia.net

- in theory, no "digital decay"; Boltzmann-entropy differing from Shannon-entropy; option to chisel zeros and one or whole web-sites in stone like an ancient epigraph, as has been drastically performed by Joachim Blank / Karlheinz Jeron 1999 in the exhibition *net_condition* for Natalie Bookchin's and Alexej Shulgin's *Introduction to net.art* (1994-1999) = www.easylife.org/netart; catalogue: Timothy Druckrey / Peter Weibel (eds.), *net condition*, Cambridge, Mass. 2000

- erasing records; artists created artificial information deserts and voids in cyberspace indeed, such as Mark Napier (New York) with his project *The*

Landfill, turning any content of web-pages into graphical raw material. But such aesthetic interfaces hide the digital truth behind the simulacra. The more radical version is the cookie (micro-program) *ArchiVirus* created by Manu Luksch, Arnim Medosch and R. Steckel (to be copied from the internet on one's own computer) which decomposes textual documents on the hard disk into its ingredients; alphabetically sorted, all the letters of a file appear on the screen, sense-less, but as a kind of raw material for composing new texts

- crucial difference between media art which is simply represented, indexed and mapped online, and the Internet itself as the material for artistic work, like art produced in HTML code itself, using ASCII-symbols of the source code of homepages (as done by the artists Blank & Jeron (Jodi) = Inke Arns, "Unformatierter ASCII-Text sieht ziemlich gut aus". Die Geburt der Netzkunst aus dem Geiste des Unfalls, in: Kunstforum International vol. 155, 236-242

- Vera Kuni differentiating between technical emulation and "conceptual" emulation = 2007: 311, resulting in a re-creation while preserving the original concept - the diagrammatic preservation of media art

- what had been the cultural-historical "context" for previous art works, today replaced by a techno-media ecology as Internet browser "environment" - consisting of plug-ins and image, text or sound formats (un/compressed) like .jpg, .mov

- Jodi's ASCII art displaying raw source code itself. "No other style of net.art reflects so directly on the nature of the Web as medium." = Galloway 2004: 220

- conservation of new media art challenged by the the obsolescence of digital technology accelerating in ever smaller intervals. The planned ephemerality of Fluxus (video) art (Nam June Paik; Wolf Vostell) unintentionally correlates, in the analog signal domain, with the ephemerality of Internet art in the algorithmic domain

- http://newmedia.umaine.edu/interarchive/three_threats.html: a dynamically generated synopsis of the site 'Three Threats to the Survival of New Media' in printable form; the interactive version at http://newmedia.umaine.edu/interarchive/three_threats.html

- "The centralized storage strategy that has served as the default preservation paradigm for culture in the 18th through 20th centuries will utterly fail as the preservation paradigm for the 21st. Archivists specialize in keeping the works in their care as static as possible, but new media survive by remaining as mutable as possible

- archaic work no longer functioning with current browsers; most external links expired; no more interface for storage medium; demagnetization

- remaking "variable media" from archived screenshot evidence and few of textual records, vs. emulation, as functional re(non-)interpretation; different from reenactment of historical events by amateur actors

- term "archive" frequently applied to cultural memory institutions such as traditional museums and libraries. But in this media alliance, culture should not be thought of by de-differentiating its storage media. The notion and the institution of the archive dissolves in(to) the Internet. Let us mention, f. e., the HILUS intermedial "Informationssystem Kunst + Neue Technologien" (based in Vienna); advertising postcard declares three sections: "*ARCHIV*/Bibliothek, *ARCHIV*/Videothek, *ARCHIV*/CD-Rom-Sammlung". HILUS Intermediale Projektforschung beendete seine Tätigkeit mit dem 31.12.1996; <http://thing.at/hilus/server2.htm> (1992-1996)

- will the future experience these works as physical traces (hardware) or rather as coded documentation, or in its dialectic synthesis which is emulated media artifacts

- radical change in the engineering of cultural tradition with the digitization of analogue (signal-based) audio-visual media art archives (sound art, video)

- <http://www.archive.org> aware of the accelerating obsolescence of media art Web pages in the Internet; it provides for a symbolic time machine: the so-called Wayback Maschine. For an Internet address (URL) it presents a chronologically ordered list of links to the same web page at different times

- "The Internet Engineering Task Force develops "technical standards that give a unique identification name to digital documents. These uniform resource names (URNs) [...] could supplement the URLs that currently access Web documents. Giving a document a URN attempts to ensure that it can be traced after a link disappears" = Kahle 1997: 83

- collecting principle of the museum and storage principle of computing belonging to different eras, even if they co-exist in the present. For dynamically generated web content of the Internet, no archive (the "dark web")

- *Permanence Through Change: The Variable Media Approach*;
http://www.variablemedia.net/e/preserving/html/var_pub_index.html

- media-archaeological imperative to preserve the technological message of media art, not only its aesthetic content. "Marshall McLuhan once claimed that the medium is the message. Replace medium with format. How far does it hold true? And how much may we permissibly change the message in order to give access to it, in a newer format, say, or over the Internet?" = Ray Edmondson, AV archiving philosophy - the technical dimension, in: Proceedings of the IAMI-IASA Joint Annual Conference, Perugia 1996, xxx no. 8 (November 1996), 28-35 (29). "Marshall McLuhan once claimed that the medium is the message. Replace medium with format. [...] Whenever content is moved from one format to another, *what is lost or chanced* and *does it matter?*" = George Boston, lecture at IAMI/IASA Joint Annual Conference, Perugia 1996

Towards the dynamic "archive"? Rhizome ArtBase (since 1999)

- EAS emulator service

- ISO file an "image" of a CD/DVD; using a burning program like Nero, or ImgBurn, to burn that ISO file directly to a disk; Tim Fisher, updated October 20, 2016; "single file that's a perfect representation of an entire CD, DVD, or BD. The entire contents of a disc can be precisely duplicated in a single ISO file. Think of an ISO file like a box that holds all the parts to something that needs built - like a child's toy you might buy that requires assembly. The box that the toy pieces come in does you no good as an actual toy but the contents inside of it, once taken out and put together, become what you're actually wanting to use" = <https://www.lifewire.com/iso-file-2625923>, accessed 24 March, 2017

" e. g. image of Operating System MAC OS 9, put onto an emulator; accompanied by "delta file" to record just the modifications

- taking care of migration of emulators, instead of migrating every single web art work content; EML (emulator); Rhizome strategic decision: concentrate on art works based on custom computer software / OS / browser, unequal independent media (archaeological) art from scratch

- "Webrecorder" (free software, deposited on GitHub) allowing for "archiving" one's personal encounter with the Web / symmetrical web archiving; recording of interaction with the web-site within one browser / record traffic between browser installed on PC and Internet, as "performative archiving"

- moving image portals like Like YouTube; Internet itself the dynamic library of performative media art, autopoetically prolonging its tradition by countless data file copying and mirroring the operating system; when the technical, infra-structural context expires, the records will expire as well

- digital culture aware that there is no work for eternity any more, resulting in the preemptive archival perspective of *futurum exactum* for ephemeral technologies like software code, websites, moving images and sound, interactive games, and browsers. Since contemporary computers are mostly unable to "perform" many of the artworks as they were originally experienced, the Rhizome initiative in New York City (in affiliation with the New Museum of Contemporary Art) started its Digital Preservation program so that net art works from the recent but technologically dis-continued past may be reperformed in their media-environmental context, with an emphasis on providing contemporary users "a sense of their initial form" URL ??? - which is the phenomenological, human-oriented approach to preservation of media art; media-archaeological alternative sets priority on the preservation of the underlying technology which is the generative grammar of "aesthetic knowledge" behind (genotypal rather than phenotypal)

- Rhizome's ArtBase less an online archive but collection of born-digital art (net art works and other forms of projects with online elements). Its primary task is up-dating obsolete code. As a challenge to inherited museum authority for cultural heritage preservation, its focus is on the development of open source web tools "to decentralize web archiving and software preservation practices" = [https://en.wikipedia.org/wiki/Rhizome_\(organization\)](https://en.wikipedia.org/wiki/Rhizome_(organization)), accessed March 13, 2017; ensure continuing access; conceptually, *open source* does not simply mean the media-political for open domain, but to reveal its algorithmic structures. Rhizome launches social media "archiving" tool Colloq which

replicates the interface of social media platforms - once more, the phenomenological appeal is given priority, by re-generating its operating systems. Even if the inside of the algorithmic machine is the pre-condition for such sensual preservation, the emphasis is not on its insight. In its media-phenomenological orientation, "Colloq pays special attention to the way a user interacts with the social media interface at the time of creation, using a technique called 'web capturing' to store website behaviors" = *ibid.*. For the art blog VVORK, Colloq used to archive the entire website. "Archiving VVORK allowed Rhizome to tackle the challenge of archiving embedded video content, which is often hosted on a third-party site" = *ibid.*, different from the limit of the Wayback Machine to non-dynamic objects: website previously archived by Internet Archive, "but this recording did not include embedded media like videos that Colloq was built to capture" = *ibid.*; Jon Ippolito: "you're going to get the experience of interacting with the actual site" = *quoted ibid.*; performative *historical re-enactment* rather than operational techno-archival display

- since 2016, Webrecorder tool as free web archiving tool "allows users to create their own archives of the dynamic web" = *ibid.*, rather than static webpages; classic archival terminology starts to be misleading, demanding replacement by a more "born-digital" terminology of such storage such as *embedded software*. Web 2.0 trans-archival ethics (like social tagging in virtual museology) is an attempt to place web preservation tools in the hands of individual users. Web historicism: "It uses a 'symmetrical web archiving' approach, meaning the same software is used to record and play back the website. Webrecorder actually records users "browsing the site to capture its interactive features" = *ibid.*

- Rhizome's oldweb.today project; view archived webpages within emulated versions of legacy web browsers - dissimulating the contemporary Internet itself; new media historicism: project gives users a "deeper understanding of web history"; browsing environments alter one's experience of the internet. "It is an example of 'Emulation as a Service' technology, imitating old software programs so that they can run on new computers" = *ibid.*. This asks for a media-archaeologically reminder of the metahistorical theory of computing itself: New computers with the very symbolical recoding of obsolete computer hardware are still based on the Universal Turing machine model - which deserves to be placed into the center of discussing digital media art preservation, and to path a way through the growing confusion of key terminology ranging from "updating", "preserving", "reenacting", "archiving" to "restaging"

Archival need for re-operative hardware (or its emulation): U.S. Census files

- for compilation of decennial population census in the early sixties, U. S. Census Bureau retaining records in what it regarded as permanent storage. "In 1976, the National Archives identified seven series of aggregated data from the 1960 Census files as having long-term historical value" - which is the archival decision. "A large portion of the selected records, however, resided on tapes that the Bureau could read only with a UNIVAC type II-A tape drive. By the mid-seventies, that particular tape drive was long obsolete, and the Census Bureau

faced a significant engineering challenge in preserving the data from the UNIVAC type II-A tapes. By 1979, the Bureau had successfully copied onto industry-standard tapes nearly all the data judged then to have long-term value" = "<http://lyra.rlg.org/ArchTF/tfadi.intro.htm#fragility>; data rescuing challenge a signal event; moved Committee on the Records of Government six years later to proclaim that "the United States is in danger of losing its memory"; when computer tapes containing the raw data from the 1960 federal census came to National Archives and Records Service, only two machines operative for reading those tapes: one in Japan "and the other already deposited in the Smithsonian as a relic" = Committee on the Records of Government 1985:9, 86-87)

Re-enactment of *The Speaking Clock*

- several compatibility layers (immanent "interfaces") within computers; translates previous operating system requests into the "language" (syntax) of new (WINE); triple strategy: maintaining hardware; emulating operating system to maintain the time-critical (not just logical) behaviour; like printing press: re-create "matrix" for new series of lithographic microprocessors (electronic core devices): embodiment of logics.

- structural architecture of electronic and computational media allowing for a *non-historicist* form of preservation which is the co-originary re-creation of a hard- and software logic instead of the uniqueness of its once individual implementation

- preservation of computer not reducible to the "ontology" of the algorithmic archive; loss of the real hardware support of media art (by migrating its data) would make posthumous investigations into the technological *a priori* of its aesthetic phenomena impossible. For historians it is imperative *not* to substitute the original archival record by a high-resolution copy

- John Cayley's poetry generator *The Speaking Clock* as example of "ergodic art": Espen Aarseth, *Aporia and Epiphany in Doom and The Speaking Clock. The Temporality of Ergodic Art*, in: *Cyberspace Textuality. Computer Technology and Literary Theory*. Edited by Mary-Laure Ryan. Bloomington and Indianapolis: Indiana University Press 1999, 31-41