[ON COMPUT*ING*]

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EPISTEMOLOGY OF COMPUTATIONAL MEDIA

Operative diagrammatics

- media archaeology concerned with media on their structural (Foucault's *archive*) and on their machine level; operative diagrammatics understands media as materiality-in-action; mathematics time-critically and micro-temporally incorporated into the machines

- mathematical objects: no sensory existence in themselves but visual in geometry; a square's drawn into sand induced Pythagorean mathematical reasoning, even though its visual properties are no evidence in themselves, visual instantiations (operative diagrams) derived from mathematical structure; ancient Greek notion of *idea* derives from the linguistic root "w(e)id" = to see, to know (derivation contested by Edwin D. Floyd, The Sources of Greek "(H)Istor" "Judge, Witness", in: Glotta LXVIII (1990), 157-166)

- diagrams not simply forms of two-dimensional visualization of logical reasoning but symbolical machines themselves - though depending upon the human mind as "interpretant" (Charles S. Peirce) to operate them in the one-dimensional time domain; human interpretant is replaced by algorithms in technical computing[1] as expressed in the "impulse diagram" of clocking and computational cycling units, analysable by the "Logic analysator". A (formerly) linguistic proposition becomes machine.

- programming the computer, in its media-archaeological "epoque" (which is meant chronological and functionally time-invariant at the same time), is closer to the idiosyncacies of the hardware than to the logics of the reasoning mind; therefore Assembly - different from "high level" programming languages - remains close to the machine, culminating in the single key to operative one bit

Symbolical notation as (re-)construction of a machine: From YUGO back to Babbage

- construction "manual" (German *Handbuch*) serves for enacting a machine presence, while at the same time being a diagram of operative media epistemology as applied object-oriented media ontology in the sense of Ian Bogost's conceptual "carpentry"

- YUGO / Zastava. Owners Workshop Manual, Somerset (Haynes Publishing Group), 2nd ed. 1990: This British manual is not only readable as a text but goes down to the minutest detail - this is a real paper machine. It allows to deconstruct and to reconstruct a Yugo from scratch (esp. my favourite: the 45 A

[1] See Frieder Nake, Das algorithmische Zeichen und die Maschine, in: Hansjürgen Paul / Erich Latniak (ed.), Perspektiven der Gestaltung von Arbeit und Technik. Festschrift für Peter Brödner, München / Mering (Rainer Hampp) 2004, 203-223

series). The visual algorithm of the manual is convincing: "The tasks are described and photographed in a step-by-step sequence so that even a novice can do the work" - which is chronophotography in the best pre-cinematographic tradition of Marey and Muybridge" (p. 5). And the cover has a jacket comment on the series: "Every Manual based on a complete Stripdown and rebuild". To know how to take apart (to dis-assemble) is to "analyze" a machine - be it a car, or a computer.

- Babbage invented his "mechanical notation" in order to avoid the time- and cost-consuming task of actually building a designed machine by handicraft. The hand becomes a symbol-drawer instead of ("hands on") "hand-writing"

- Babbage inspired to design his Difference Engine to avoid the errors which take place in hand writing and copies of printed tables of logarithms (Prony)

- Martin Campbell-Kelly (ed.), The works of Charles Babbage vol. 3: The Analytical Engine and Mechanical Notatiton, London (Pickering) 1989; Charles Babbage, Laws of Mechanical Notation, http://history-computer.com/Library/CharlesBabbage:LawsOfMechanicalNotation.pdf

- Reuleaux' symbolical notation accentuates the machinic modules; Babbage accentuates temporal flow; Berz 2001: 181; "mechanical notation" allows to reproduce the procedural behaviour of the designed machine, expressed in his so-called Timing Diagram (cycling units), and Flow Diagram

- Doron Swade, Automatic Computation. Charles Babbage and Computational method, in: The Rutherford Journal = http://www.rutherfordjournal.org/article030106.html

- flow chart in computer programming today introduces a symbolic temporal order into the machine regime. The hand here operates on the machine symbolically, not materially

- to perceive technology-in-time: On the one hand, Babbage's Analytical Machine was not realized in 19th century due to mechanical, financial and epistemological restrictions; on the other hand, his mechanical notation can be re-enacted today without loss (due to "historical gap" inbeween). No media historicism - a double bind of media history and media archaeology

- on logic branching with Babbage: Andrew Ferguson, A History of Computer Programming Language = http://cs.brown.edu/~adf/programming_languages.html

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

- contemporary media culture taking for granted that "the computer" is almost automatically identified with digital computing. The analog computer as apparatus may have been a dead end in the history of calculating technologies. But taken as a method, analog mathematical modelling and continuity (which

is the core of analog computing) remains a radical alternative to algorithmic computation.

- Simondon conceptualizing evolution of *analog* technical devices (techno-logical individuations); for computational machines, back to Plato; analog (and therefore as well future quantum-)computing make a decisive multi-valued difference

- "post-computational" will not (only) be quantum computing and hypercomputation (Nückel) but a re-turn (recursion) of analog computing
For analog signal transducing technologies (electro-engineering), philosophy is rather not responsible. All is different with techno-mathematics; two deeply philosophically routed disciplines, mathematical reasoning and philosophy of technology, here merges.

- 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, though, simulation by analog computers performs 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 are coupled according to a model analogous to the simulated object. Analog machinery is not a metaphysical, instransitive abstraction from the world (a "language"), but part of physics itself - transitively, just like science itself might be called a (temporary) model for linking the physically real, mostly unaccessible world to what can be perceived by human (measuring) senses, as defined by Max Planck

- man-made, thus: historically variable (in Gianbattista Vico's sense), analogous to history itself as a *cultural modelling* of time.

- analog computing: mathematics becomes experimentation itself; message of analoge computing: doing mathematics in the engineering way (different from Claude Shannon's mathematization of engineering itself)

- media-archaeology accentuates the man / machine difference in interface design; still, logic of computing is not alien to human intuition, but rather dis-covers the human as mathematical machine itself (with Turing)

- computational knowledge; Leonardo Torres y Quevedo, designer of general-purpose automata (especially algebraic equation solvers), once adressed as a great mathematician, responded: "Because I invented an algebraic machine? No, that is not so; the machine knows much more mathematics than I" = quoted here after: A Computer Perspective. Background to the Computer Age, catalogue (by The office of Charles & Ray Eames) 1973 to the exhibition at the IBM Exhibit Center in New York, New Edition Cambridge, Mass. / London (Harvard University Press) 1990, 68

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

- analogization not a construction of cultural knowledge, but an implicit knowledge from within nature itself; scientists amazed[2] by the analogous behaviour of a swinging pendulum (a mass, suspended at a leaver) and a "Schwingkreis", an electronic short-circuiting of induction (coil) and capacity (condensors); Fig. 1.1 and fig. 1.2 in: Giloi / Herschel o.J.: 12

- syllogistic medium 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 = 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 derivate of the radically matrix-based mathematical tool *Matlab*, a commercial product of *The MathWorks*) differ 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 occuring in a useful device or system <...> a time-varying quantity"[3]. 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

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[2] E. g. Heinrich Barkhausen, Schwingungslehre, Vorwort, xxx

[3] Edward B. Magrab / Donald S. Blomquist, The Measurement of Time-Varying Phenomena, New York et al. 1971, 1

authenticity has been directed at obtaining authentic program texts. <...> as with musical scholarship, this texual approach permits the informed and explicit filling in of lost textual fragments <...>."[4]

- 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

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

- analog computing (different from analog-to-digital conversion of physical signals into data) compatible with the physical (therefore temporal) world itself, when becoming part of the very system which it electro-physically simulates

Simulation by numbers

- time axis manipulation not easily be peformed with physical mechanism, thus engendering knowledge: "Der Erkenntnisvorteil von Simulationen liegt in ihren Extrapolationsmöglichkeit für Bereiche, die zu klein oder zu groß sind, zu schnell oder langsam ablaufen"[5] - chrono-morphing experimental events or even creating "events" which otherwise have not been percetible to human senses.

- digital simulation of physical experiments leads to "artefactual events", revealing mathematical moments of the real: "All discretization techniques present the possibility of roundoff errors or instabilities creating undetected artifacts in simulation results."[6]

- numerical experiments, that is: simulations performed by the digital computer, are diagrams gone operative. Inbetween the physical laboratory experiment on the one hand, and theoretical physics on the other, such simulations realize a true media theory, that is: Theoretical reasoning is being algorithmically implemented in the real world (like the computer has been born out of a theoretical mathematical question, the *Entscheidungsproblem*, with Alan Turing 1936). Being in the world - that is, being in time and thus: happening as events, complex models can result in phenomena which have not been envisioned by the author of the program, thus generating unexpected phenomena, which is: information in the true sense of the mathematially informed communication theory in engineering[7]

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4 Campbell-Kelly 2000: 399

5 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 (448f)

6 Eric Winsberg, Simulated Experiments: Methodology for a Virtual World, in: Philosophy of Science, 70 (2003), 105-125 (120)

7 See Johannes Lenhard, Mit dem Unerwarteten rechnen? Computersimulation und Nanowissenschft, in: Alfred Nordmann / Joachim Schummer / Astrid Schwarz (Hg.), Nanotechnologien im Kontext, Berlin (Akadem. Verl.ges.) 2006, 151-161 (esp. 159f)

Computational "society" with Tarde and Latour

- material hermeneutics (and forensics[8]) does not care about "social" implications. Media archaeology rather deals with techno-logical individuations in Gilbert Simondon's sense. Any techological analysis of networks goes down to the hardware (fiber optical cables), protocols (Alexander Galloway) and the source codes ruling communication.Technological objects enact an agency of their own, once their electronics and wiring or storage is read closely, and is - for the moment of analysis - consciously detached from historical, biographical, and social contexts[9], rather looking for non-"social" forces with*in* (or as a *parergon*) of technological formations themselves. Latour's actor-network model liberated the "social" from its limited anthropocentric sense.[10] Still, such extended usage of the term "social" carries with it the metaphorical ghost of a human-like collective. Different from ANT, media archaeology keeps both regimes analytically apart; it rather replaces "society" by cybernetic systems theory. André-Marie Ampère associates in his *Tableaux synoptiques des sciences et des arts* (3. Tableau) the *critique archéologique* with *statistique* (social economy) and *cybernetique* (gouvernment); „l´archéologie <...> va naturellement se placer entre l´ethnologie et l´histoire“.[11]

- perspective of Science and Technology studies upside down; ANT can not explain techno-logics either; not only that technologies are part of the "texture" of society = Latour, Pandora's box, but the loom itself; requires a radical shift of perspective from outside (intransitive) to "from within" technologies, that is: making their operative enunciations media-theoretically explicit. Source code, executed by computing mechanisms, actually "speaks" itself (Geoffrey Cox)

- 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 [= "Die Philosophie der PCM", in: Shannon 2000, 217-236]; verbal, diagrammatic and algebraic language describing the techical transfer of speech by pulse code modulation (that is: analog-to-digital sampling, different from FM) is not philosophical but techno-epistemic in the most precise sense

Computing and its "musicality"

- computer processing whatever can be reduced symbolically to a set of

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[8] Matthew Kirschenbaum, Mechanisms. New Media and the Forensic Imagination, Cambridge, MA (The MIT Press) 2008

[9] For a more compromising version of this radical point of view see the Introduction (on "Critical Code Studies") to: Ian Bogost et al., 10 PRINT CHR$(205.5+RND(1)); : GOTO 10, Cambridge, Mass. / London (The MIT Press) 2013, 6: "CCS invites code-based interpretation that invokes and elucidates contexts."

[10] See Bruno Latour, Pandora's Hope. An Essay on the Reality of Science Studies, Harvard University Press 1999

[11] Essai sur la philosophie des sciences, ou: Exposition anlytique d´une classification naturelle de toutes les connaissances humaines, preface (xvii)

numbers and (electro- or otherwise physically) really to sufficiently distinctive binary states

- "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."[12]

- every detail regarding phyiscal tone, colour, shape and movement can, after A/D sampling, be expressed as quantified rows of digital numbers. This world view conceptually resembles that of Pythagoras, creating a media archaeological short circuit between ancient Greece and the present digital reality; the difference is the micro-physical knowledge (and Fourier-analysis) of the vibrational event. The "time" dimension has intervened itself - and at the same time been dialectically mastered by transforming it into the frequency domain

- early musical automata and musical composition games such as those designed by Athanasius Kircher in the 1660s a direct predecessor of algorithmic computer music. 224 These machines relied on automated processes that systemised the musical content and performance practices; a more meaningful connection lies not in the programmability of the cylinders and the programmability of modern computers, but instead in the regular revolutions of the pinned musical barrels and the constant clock frequency in modern CPUs

- "musical" demonstration of hard drive’s dynamic temporality: Harddisko (2004) by Valentina Vuksic; pieces Analog HD1 (2011) and Analog HD2 (2012) by Gijs Gieskes conceptualise the hard drive’s physicality

- media-archaeological understanding of digital media does not neglect the physical real machine, the execution, the operative technology; when taking the physicality and possibility of malfunction into account, then the connections between 5th century Greece and the digital present will look very different. In real signal processing, it is impossible to "count" because counting requires that the machine runs without frictions, that the timekeeping is absolute. But the machine is always something more than a symbolic configuration. The operational machine is always trans-symbolic

Algorithmic sociology

- Furet's *histoire sérielle* not simply mathematically investigating "big data" (quantiative history) but identifies patterns and correlations (close to "Digital Humanities" today), "temporal series", "given intervals", generally measured "annually". This corresponds with the aesthetics of minimal music which somewhat sonifies such temporal series which extend to non-anthropocentric series of data[13]

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[12] Denis Guedj, Numbers. The Universal Language, xxx (Thames & Hudson) xxx, 59

- algorithmic sociology = predictive statistics. "Will we become the atoms in the 'social physics', first dreamed by the founder sociology Auguste Comte in the middle of 19th century?", Lev Manovich asks in his presentation of an algorithmic tool to compare facial expressions in "selfies" collected from social media such as Instagram in order to detect the distinct "visual signature" of individual cities.[14] Gabriel Tarde in late 19th century developed an expressed ‘archaeological’ sociology, closer to statistical data operations than to human subjective or collective agencies[15]; „Il est le plus propre à éclairer les faits sociaux par leur côté régulier, mesurable et nombrable“; „il s´ensuit que la statistique sociologique decrait s´y placer“, by „enregistrements stériles", in fact „l´emploi de la méthode graphique de M. Marey ou l'observation des maladies par le myographe, le sphymographe, le pneumographe, sortes de statisticiens mécaniques des contractions, des mouvements respiratoires.“[16] In *Le Mouvement* (1894), Marey calls the graphical curves "the language of the phenomena themselves"[17]. Tarde defines "les études archéologiques et les études statistiques“; statistians, like the archaeologist, „jette sur les faits humains un regard tout abstrait et impersonnel“ - Foucault's posthumanistic archaeology not *avant*, but *à la lettre*[18]

Discrete methods: Writing the past retro-actively

- radical media archaeology a non-historicist investigation into technologies from the present past. It is not necessarily about contextual information about past media, but a close reading which gets into contact with technological media in their radical operability and temporality itself. Media archaeological as research method restrains from the historian's interpretative touch 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

- 6th December 1896 Freud writes to W. Fließ about his assumption that psychic mechanism grows in layers, which are occasionally / event-driven re-organized"[19] - dynamic media archaeography as it happens in the stored-program computer (von Neumann), in synchronous layers, describes techno-

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[13] Kusch 1991: 20, referring to serial history in terms of Le Roy Ladurie. See François Furet, Quantitative methods in history [FO 1971], in: Jacques LeGoff / Pierre Nora (eds.), Constructing the Past, Cambridge (Cambridge UP) 1985, 12-27 (14)

[14] E-mail disseminated by Lev Manovich on May 27th, 2014. See www.selfiecity.net

[15] Gabriel Tarde, Les lois de l´imitation, Paris (Félix Alcan) 1890, chap. IV (Qu´est-ce que l´histoire?), section „L´Archéologie et la Statistique“, esp. p. 99 and p. 114. See Bruno Latour, Gabriel Tarde und das Ende des Sozialen, in: Soziale Welt Jg. 52, Heft 3, 2001

[16] Gabriel Tarde, Les lois d´imitation, Paris 1890, 122f

[17] Quoted here after Giedion 1982: 40

[18] Gabriel Tarde, Les lois de l´imitation, Paris 1890, chap. IV (Qu´est-ce que l´histoire?), Absatz „L´Archéologie et la Statistique“, 99 u. 114

[19] Sigmund Freud, Aus den Anfängen der Psychoanalyse 1887-1902, xxx, 185

logical recursions, dis- and replacements (McLuhan's "tetrads")

- discontinuity between analog past and digital present "brings an accelerating historicization of technological forms which have patterned culture for centuries and patterned media studies at least since McLuhan" (Mark Goble); "Freudian concept of 'retroaction' (in French “après coup”; from German “Nachträglichkeit”), turning it to new, non-psychological ends" = Exposé 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 redefine our understanding of cultural engineering in the past

- digital media today transform 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 idas 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

- in digital data circuits, "retro-action" not a translation between the past and the present any more, but requires a cybernetically closed circuit (the feedback-option / back channel). When we load a document, it does not come from a materially, 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" transform narrative aesthetics into non-discursive configuration of events - a formal, algorithmic chronography

***Er/zählen*: narrative *versus* calculation**

- 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"

- Computers practically transform narrative aesthetics into non-discursive, algorithmic configuration of events; the operation of the machine itself has 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" - as analyzed by the archaeologist Denise Schmandt-Besserat (stones included in a clay cube, sealed, with their written on it) or in computer hardware)[20]

- 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 allows 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.[21] The 23 Latin letters once saluted by Lucretius as elements of an unlimited combinatorics of thought[22]. 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“[23]. The alphabet is 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, Apokatastatis panton, published in: Max Ettlinger, Leibniz als

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[20] Denise Schmandt-Besserat, Before Writing. From Counting to Cuneiform. Austin/Texas 1992

[21] Ulrike Steierwald, Wissen und System: zu Gottfried Wilhelm Leibniz´ Theorie einer Universalbibliothek, Cologne (Greven) 1995, 65

[22] *De rerum nat.* 1. 823-827.

[23] Leibniz to Herzog Johann Friedrich von Braunschweig-Lüneburg, ca. 1671. See Hans Blumenberg, Die Lesbarkeit der Welt [*1983], 3rd ed. Frankfurt/M. 1993, 121-149 (128ff), on Leibniz´ spectulative *Apokatastatis* (fragment 1715)

Geschichtsphilosoph, München 1921, 31; see Bernhard Siegert, Frivoles Wissen. Zur Logik der Zeichen nach Bouvard und Pécuchet, in: Hans-Christian v. Herrmann / Matthias Middell (eds.), Orte der Kulturwissenschaft. 5 Vorträge, Leipzig (Universitätsverlag) 1998, 15-40, esp. 28-33. Leibniz even reduces 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."[24]

- discrete recording at odds with continuous processing. How then 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.[25] Natural language is made up of discrete, finite elements (phonems) so that all descriptions of continuous processes happpen by a finite discrete sequence of finite elements <Pattee 1974: 130>. Leibniz offers 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."[26]

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

- media archaeology dealing with the new possibilities of "petits 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-aisthetics) 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 pixeled, that is: digitally coded, an image looses 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. Now we reach the limit of digital computing: Although his heart (micro-ship) is materially built on sand (silicium), he is not able to calculate the random distribution of sand without aliasing effects. And a human image drawn into the sand will (with an

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[24] Brief Leibniz v. 18. May 1696, zitiert nach: Hans J. Zacher, Die Hauptschriften zur Dyadik von G. W. Leibniz. Ein Beitrag zur Geschichte des binären Zahlensystems, Frankfurt/M. (Klostermann) 1973, 209

[25] Laszlo von Szalay, Moderne Technik. Elektrotechnik, Berlin (Safari) 1954, 386

[26] See Bernhard Siegert, Passage des Digitalen. Zeichenpraktiken der neuzeitlichen Wissenschaften 1500-1900, Berlin (Brinkmann & Bose) 2003

allegory designed by Michel Foucault) vanish in specific waves in ways no digital computer will ever be able to emulate (except quantum computing). This image, after a while, will rather look like the jammed images in early analogue TV

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, here: Introduction: Paperworlds. Imagining the Renaissance Computer, 1-17

- C. W. Ceram´s "archaelogy of the cinema": "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"[27]

Streaming: The digitization of records from the past

- light and sound signals belonging to the regime of the real, while their digital sampling translates 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 memorizes 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

[27] 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

- with an analog-to-digital converter, the sampling rate controls how many samples are 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 = transformation of a temporal function or sequence of signals into a spectrogramm; 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 calculates 10 000 letters and thereby makes live finitely countable, explicitely annalistic[28]

- according to Norbert Wiener, telegraphic transmission of a human being, if sufficiently describes as information; "streaming" data is 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 <continuous? 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 insetallation QuickTime Movie. The analoge becomes a nostalgic re-entry

- dis-affection; media-archaeological gaze matches machine aesthetics itself which is implanted into the human *mind* (like Turing could imagine the human as "paper machine"

COMPUTING

Programming

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

- "After American weapon factories during the Civil War had already delivered guns which exchangable parts, World War One extended the exchangability of guns like the notorious 08/15 to an extend that its single parts could be produced in bicycle and typewriter facturies as well. Only such really modular systems, as having been claimed by Babbage for his proto-computer already,

[28] Leibniz in Ettlinger 1921: 29

inagurated 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 the Academy of Media Arts, Cologne 1997 (Walther König), 348-363 [transl. W. E.]

- Sybille Krämer, Symbolische Maschinen: die Idee der Formalisierung in geschichtlichem Abriß. Darmstadt 1988; Bernhard Dotzler, Papiermaschinen: Versuch über Communication & Control in Literatur und Technik, Berlin 1996; Anthony F. Hyman, Charles Babbage, 1791-1871. Philosoph, Mathematiker, Computerpionier, Stuttgart 1987; Peter Berz, 08/15. Ein Standard des 20. Jahrhunderts, Munich (Fink) 2xxx; Michael Conrad, The Prize of Programmability, in: Rolf Herken (ed.), The Universal Turing Machine. A Half-Century Survey. Hamburg-Berlin 1988

- irreducible asymmetry between time- versus storage-orientated economy in computing linked to the most basic level of programming aesthetics: Though to write a program in the programming language is easier, it can not be used directly since it must first be translated into machine codes. After the translation, the program written in machine languages again becomes 3-6 times longer and needs 3-6 times more memory; time saved in preparing the program had to be paid with increased memory, that is by a still larger amount of hardware

(back) into counting: "Radical" media archaeology

- humans count (add) 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 the machine where algorithmics precedes narrative

- "radical" refers to the affinity between media archaeological analysis and mathematics, epitomized in the radical square root. Fundamentally media archaeology understands the *arché* in its mathematical sense: algorithmic rooting in numbers; Lacan, on the intrusion of symbols like the square root: this happens all of the sudden, but still creates its own (pre-)history

- digital computer (on silicium chip) does not count 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 oppositive 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 critial 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: de-couples "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: quarz oscillator) and a logical clock (software); computing turns time-measurement into information, resulting in "multiple times"[29]

- according to Helmholtz, inner ear acts as a Fourier analysator, machinic 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 is named ›Accumulator‹ in early-Mikroprozessors (8-Bit-Prozessors) like Z80, where arithmetic and logic operations take temporarily place

Still human? Counting with fingers

- topic of "adding" seduces to start with Leroi-Gourhan: with the human hands which enable tasks resulting in culture (a cultural technique). But let us look at the more elementary level: not just hands but fingers which literally lead to digital counting in its most basic form: adding to ten decimal numbers.

- intuitive tuning instead of counting = 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 Turing state: 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" aus Soroka 1954, 2 f., in: Pflüger 2005: 30. Pflüger asks "ob der Computer überhaupt 'rechnet'"; rather: "symbol manipulating device", operating on

[29] See 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

binary symbol chains. Rather information processing in terms of entropy (Shannon); "Rechnen im herkömmlichen Sinn stellt dabei nur eine operative Möglichkei tunter anderen dar." Opening the notion of computing.

- treating binary discrete electronic states as "numbers" is an arbitrary symbolization; binary computer: counting with integers; analog computer: real numbers

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 circuity.

- 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 = "eine Geschichte <?>, 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"[30]; *dissimulatio artis* in rhetoric

- Jacques Lacan rewriting Sigmund Freud with computing; "Freud's psychoanalysis was based only on the first industrial revolution, not the second"; theoretical distinction by Jacques Lacan, the real, the symbolic, and the imaginary, got with Kittler a "historical base": "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)

[30] Arndt Niebisch in Pál Kelemen et al. (eds.), Kulturtechnik Philologie, Heidelberg (Winter) 2011. : "Die Liebe zur Ziffer. Positionen einer posthumanen Philologie", 163-183 (177), parphrasing Krämer

Archaeology, Computing

- *there is no memory* in technology unless expressed symbolically like the very term "memory" for permanent (ROM) and ephemeral (RAM) data storage in early digital computing; instructions like "Memory" in the text saving menues of computer software are a semantic archaism. The 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

- industrial and rubbish archaeology analyses present cultures in *real time*. Memory is not immediately linked to the past but rather radically present. The increase of archaeological disorder in abondonment processe the law of history as phycics of time (Bolzmann). Mathematically informed archaeology practices *cluster analysis*. The historiographic concepts of past times have been 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* = metonymic transformation of non-intuitive data into graphics. Thomas Quarry announced it in an advertising for IBM from Casablanca where Jean-Jacques Hublin unearthed a few fossiled 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"[31]

- Sphinx sculpture in front of the Cheops pyramid has been restored by the computer in detail; Mark Lehner of the Oriental Studies Institute (University of Chicago in Illinois) has overlapped photographies of the sphinx with portraits of pharaoe statues and by photogrammetric composite pictures reconstructed the most probable archetype of the sphinx which might bear the features of pharaoe Chefren (4th dynasty)[32]

- project undertaken by the Parisean École Française d'Extrème 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, have to be restored to their previous placement. An infographics company provides three-dimensional photographies as computer modelling of the temple, serving as conceptual grid to insert the fragment into.[33] Once again, the computer provides a better memory of waste than historical, that is: human imagination can cope with

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[31] In: *Wired* 3.03, March 1995

[32] Notice in the *Frankfurter Allgemeine Zeitung* from 15th July 1992

[33] "Steine mit dem Computer sortieren", in: *Frankfurter Allgemeine Zeitung* of 12th April 1995

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

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

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

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

"Toward an Archaeology of Algorithmic Architectures from Within"

- concept "living architecture" = programmable matter

[Statement on occasion of launch of Andrew Goodhouse (ed.), When is the Digital in Architecture?, Spike, Berlin, 15 June, 2017]

- a media archaeology of algorithmic architectures from within" meant as: from within the digital itself, the computer, more precisely: the so-called "von Neumann architecture" of stored-program computers in the techno-logical sense: its architecture (electronic hardware, *techné*) and archive (software, *lógos*)

- "a media archaeological understanding of the archive can situate the digital's point of origin far before the integration of digital tools into architecture practice" on the one side; in reverse: integration of computing "architecture" into architecture proper

- both "archives" and "architecture" = about tectonics = structure; computer engineering first three-dimensional, *housing* thousands of electronic tubes, then, with Integrated Circuits, becoming more and more (Moore's law) two-and-a-half-dimensional; such a circuitry not only *is* but *has* an architecture

- archaeological entropy is re-versed by informational entropy: In 1896 A. S. Murray visited the ancient site of Ephesos and reports about a state of entropy: "The entire area was overgrown with vegetation, and the few visible remains were lying about in such confusion that no definite plan could be distinguished <...>"[34] - kind of disorder which human capacities of *pattern recognition* can not decipher any more; only as data arrays such traces become readable again by a different architecture - the architexture of computational microchips

[34] Quoted after David George Hogarth, *Excavations at Ephesos, The archaic Artemisia*, London 1908, "Preface"

- computer application in Archaeology proper: quantitative / statistical analysis; Geographic Information Systems (GIS), linking data to maps; surveying of excavation, topographic and geophysical data; on-site recording of excavations and post-excavation analysis; graphic display (synthesis) from same data set, reconstructions and simulations

- S. Ross, J. Moffett and J. Henderson (eds.) Computing for Archaeologists (Oxford University Committee for Archaeology Monograph No.18); P. Reilly and S. Rahtz (eds) 1992 Archaeology and the Information Age: A global perspective (Routledge, One World Archaeology 21); S. Shennan 1988 Quantifying Archaeology (Edinburgh University Press); C. Orton 1980 Mathematics in Archaeology (Cambridge University Press)

- ruin (heap of stones) of former *Frauenkirche* cathedral in Dresden transformed into a serial magazin of shelves storing the array of the individual stones which are being digitally registered by computer programs in order to reconstruct the building out of its scattered elements. The virtual reality of the *Frauenkirche* is interval memory, memory *in the meantime*[35]

- Geoffrey Shaw´s *Legible city*, a version of which even exits for Karlsruhe, builds urban architecture by letters, thus rendering spatial data symbolically readable[36]; if a virtual space is rooted in real world at all, it is the materiality of the computing device itself; 3-D-spaces always reflects the graphic power of SGI workstations

- against the theatrical paradigm of "computers as theatre" (Brenda Laurel), that is: the visual Interface, stands McLuhan's notion of "acoustic space": computers rather as concert hall = sonic approach to (literally) "understanding" of processual algorithmics (alternative to Asymptote's *New York Stock Exchange* visual Data-Metaphors; an alert is better addressed to time-critial ears

- OPERATIVE MEDIA PRESERVATION of early digital works in architectural design is linked with the challenge of RE-ENACTING (TECHNO-)LOGICAL MACHINES. To return to the question "When is the digital in architecture?", there is 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

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[35] See Edmund Hug, "Letztlich eine Frage der Architektur", article on the CeBIT '94 fair at Hannover, in: *Frankfurter Allgemeine Zeitung* of 15th May 1994

[36] See Lev Manovich, Die Ästhetik des naviigierbbaren Raums, in: Katalog vision.ruhr: Kunst, Medien, Interaktrion, Zechhe Zollern II/IV Dortmund, xxx, 84-90 (87)

- juridical fiction developed in Elizabethan England described by Ernst Kantorowicz, The King's two Bodies, the royal office does not die with the physical body but survives as virtual body - just like an algorithm can survive its actual electronic implementation. The techno-archive's two bodies are the tectonics of computer hardware (in its von-Neumann architecture), and its algorithmic codes

- possible attendance to software performance: breaking the logic of computing itself by switching to another medium such as sound; sound as configurations of data (once oscillations have become calculable); sonicity as temporalized technology accessible *via* the ear, the human time organ. By *auralization* of computer architecture so that we can listen to the rhythms of algorithms and access microtemporalities; listening with a media archaeological ear not to content (music), but to the sonic dimension of computational architecture

TYPE-WRITING

"The gesture of programming" (with Flusser)

- Flusser on "gesture" of telephoning; concentrate on dialling. In the analog mode, there is 10 numbers 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.

- "Defining gesture as ‘a movement of the body or of a tool attached to the body for which there is no satisfactory causal explanation,’ Vilém Flusser moves around the topic from diverse angles. He analyzes each gesture as the expression of a particular form of consciousness, that is, as a particular relationship between the world and the one who gestures"; http://www.upress.umn.edu/book-division/books/gestures

- the hand "human" at all, or half way to a machine (mechanism) already? Is it an interface in the technical sense? There lies the uncannyness of the hand: Humans are 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. Data *processing* is the name given to the

manipulation of data to produce a more useful form, which we shall call *information*. <...> The sequene of operations required to perform a specific task is known as an algorithm."[37]

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 - corresponds 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[38], he is a media-archaeologist of the "digital": "Our very word 'grasp' or 'apprehension' points to the process of getting at one thing ghrough 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."[39]

- for Aristotle all sensations are *external*, for modernity the 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". While for the Aristotle all signal transmission happened in a material, almost haptic medium (*to metaxy*), media theory in times of technological media differentiates drastically

- for age of electricity, McLuhan identifies return (reoccurrence) of the primordial (oral language-controlled) "tacility". Its decisive criterium 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[40]

- correlation between discrete arithmetic numbers / couting with fingers / haptic sense: "All of these anticipate later electric forms because, like the digital computer with its mulitple 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

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[37] J. D. Richards / N. S. Ryan (eds), Data Processing in Archaeology, Cambridge U. P. 1985, 1f

[38] See Claus Pias, Die Welt des Schmoo, in: de Kerckhove et al. (eds.) 2008: 140-157

[39] Marshall McLuhan, Understanding Media,New York et al. (McGraw-Hill) 1964, 60

[40] See Till A. Heilmann, Digitalität als Taktilität. McLuhan, der Computer und die Taste, in: Zeitschrift für Medienwissenschaft 3, no. 2 (2010), 125-134 (128)

primarily tactile"[41]; electric current stroke / impulse; pointillism, Morse code) pre-figuring digitality; sampling of analog signal qualities (image telegraphy / television)[42]

- Henry Fox Talbot envisioned half way 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."[43] In a kind of unexpected recursion the artistic hand comes 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"[44]

- Flusser's definition of the photographic apparatus as "programming"

- Maurice Denise's definition of painting which resembles Clement Greenberg's notion of modernist painting as well as Michel Foucault's writing on Monet and Marshall McLuhan's famous *dictum* of the medium-as-message: "a painting, before it is a naked woman, a horse in battle, or an anecdote of some kind, is firest a flat surface covered with colored marks assembled in a certain order"[45]

- Leonardo da Vinci defines painting as half-mechanical, since it springs von mental operations but results in manual action[46]

- 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

- "The Gesture of the Programmer" (Stefan Höltgen, abstract conference Brünn, 2014); especially programming in *assembly languages*; these machine orientated languages „do things“ directly. 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/autor 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

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41 McLuhan 1964: 247 f.

42 Heilmann 2010: 131

43 Jonathan Benthall, The Computer as Medium, in: Rosen (ed.) 2011: 461-465 (461)

44 Abraham A. Moles, Introduction to the Colloquy [sc. *Computers and Visual Research*, Center for Culture and Information, August 3-4, 1968, Zagreb], reproduced in: Margit Rosen (Hg.), 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)

45 As quoted in Moles 1968 / 2011: 265

46 Leonardo da Vinci, Malerei und Wissenschaft, in: Konersmann (ed.) 1997, 93-104 (93)

programming opcodes

Not hands, but fingers: the "digital"

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

- limited manual precision in anloge computing with sliding rule; "on the other hand" infinite variability = "real numbers" which the digital computer always misses; cp. 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 induced a different kind of his philosophy; key-board of Nietzsche´s Malling Hansen; animation of the transporting ribon mechanism, clock-like; implicit turingmachine; 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 ostacles of the mechanism. It is in their operativity that technical media *time-criticvally* (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 explicitely tries to emulate 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 discoursive knowledge in the Gutenberg era.)

- The Dictionary of Typewriting, by Maxwell Crooks and Frederick Dawson, 6th edition, London (sir Isaac Pitman & Sons Ltd.) 1954 [*1919]

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

Machine-writing

- term "manu-script" does not relate to human hand-writing any more but the typographic original of the printed book[47]

- alphabetic writing (MCLuhan) pre-conditioned epistemology of analysis (elementary practive, combined with the eye: reading), *vgersus* "acoustic space" (returning with electricity)

- hand-driven phonograph / grammophone (Emile Berliner, original version; photo: Replica MAF): the ear is much more sensitive to unregularities. "Bei der Wiedergabe musikalischer Töne macht sich jede Unregfelmäßigkeit bei der Drehung der Walze, die ja durch handbetrieb erfolgt, unangenhme bemerkbar."[48]

- hand-held endoscope / stethoscope in medicine *versus* ultrasound image

- optical artefactuality of the camera objective. When Leopold von Ranke declared his mythic vanishing point of "describing just what actually happened"[49] in history as a neutralization of his subjective stance as author of historiography, this corresponds with the new, contemporary objectivist aesthetics of photography

The inhuman / machine within / defining the "human"

- David Savat, *Uncoding the Digital*. Technology, Subjectivity and Action in the Control Society, New York (Palgrave Macmillan) 2013

- identifying the sub-phenomenal machinery / media-archaeology of infrastructure: reconfiguring of "the human"; technology (or the robot) not outside of, or separable from, the human, "in both a conceptual and material

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[47] See Peter Stein, Schriftkultur. Eine Geschichte des Schreibens und Lesens, Darmstadt (Wiss. Buchges.) 2006, 176

[48] Report in *Leipziger Illustrierte* from 1878, quoted in: Herbert Haffner, "His Master's Voice". Die Geschichte der Schallplatte, Berlin 2011, 20

[49] "Bloss sagen, wie es eigentlich gewesen": Leopold von Ranke, Preface to his *Geschichten der romanischen und germanischen Völker von 1494 bis 1535* (1824), p. VI; both the translatability and the implications of this phrase are being discussed deeply in: Stephen Bann, The Clothing of Clio. A Study of the Representation of History in Nineteenth-Century Britain and France, Cambridge (Cambridge UP) 1984, 8ff

sense, just as humans are not separable from machines"[50]; following Lewis Mumford, Félix Guattari, Gilles Deleuze, "we argue that machines are social, and that what should concern us are not the actual robots, but rather the machines of which both robots and the anxieties generated around them are equally a product" (53); Heidegger's *Ge-stell*; Gehlen's "institution"; not "some lack of humanity" should concern us, "but rather how robots can help us recognise our own machinic nature, and in particular our own roles in the social machine that constructs both the robots and the anxieties around them. In short, it is the machines in our own heads, and not the robots themselves, that are at issue" (53); but: Turing test / turingmaschine (state); Gotthard Günther, "zweite Maschine"; Lacan

- technical apparatus (like the ghostly presence of the dead, incorporated in the wax cylinders of Edison’s phonograph) questions the precarious lines dividing humans from nonhumans, the creature from the inanimate, physical nature from physical mechanisms. Such distinctions kept cultural self-awareness going but became increasingly blurred through the development of advanced technological systems

- "Not the external and physical alone is now managed by machinery, but the internal and spiritual also" = Thomas Carlyle, Signs of the Times, in: G. B. Tennyson (ed.), A Carlyle Reader: Selections from the Writings of Thomas Carlyle, New York (Cambridge University Press) 1984, 35. "If a machine be defined more or less in accord with the classic definition of Reuleaux, as a combination of resistant parts, each specialised in function, operating under human control, to transmit motion and to perform work, then the labour machine was a real machine: all the more because its component parts, though composed of human bone, nerve, and muscle, were reduced to their bare mechanical elements and rigidly restricted to the performance of their mechanical tasks" = Lewis Mumford, The Monastery and the Clock, in: D. L. Miller (ed.), Lewis Mumford Reader, Athens (University of Georgia Press) 1995, 315-16; Savat / Chau, 61: Deleuze's / Guattari's "recognition that any machine is first and foremost social"; 65: "social robots especially help us recognise our own machinic nature, and help us recognise that we precisely arrange ourselves as assemblages"; 66: movie *Blade Runner* (Dir. Ridley Scott, Warner Bros, 1982): Tyrrell, whose corporation produces androids, proclaims: "Commerce is our goal here [...]. More human than human is our motto"

OPERATIVE MEDIA PRESERVATION: RE-ENACTING (TECHNO-)LOGICAL MACHINES

The operative presence of technological artefacts from the past

- media archaeological focus on the *operative being* of technological artefacts; it is 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

[50] David Savat / Christina Chau, Anxious Robots, Desiring Repression, Generating Profit, in: Transformations issue 29 (2017), 52-xxx (53)

(things) and their beeing. 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, e. g., opens a discussion to what degree "digital" communication not only comes after but actually preceeded the time of analog telephony and radio.

- media art preservation: combination of a media archaeological artefacts collection with the signal laboratory, resulting in the concept of an operative media theatre with its core theoretical assumption that a technological artefact is in its medium state only when it dramatically unfolds in signal transmission, recording and replay, or in digital symbol processing. Therefore the items are not primarily presented as objects from the past but in their presence as "time objects" (Edmund Husserl), not as frozen pieces of hardware shelved in vitrines, but focus the visitors' attention towards the inside and the function of the objects. "Open source" and "open access" is meant literally here, with a hands-on bias.

- early computer game cassette tape looks like one the million 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 looks 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 have been 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 algorithmically to reveal its latent information after 40 years. Delayed memory of such kind is 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 diagramm for a tune fork telephone

- in terms of historical research, meaning of a past material object rests in the information attached to it in the form of associated textual records[51]; media

[51] See David Crowther, Archaeology, Material Culture and Museums, in: Susan M. Pearce (ed.), Museum Studies in Material Culture, London 1988, pp. 35-46 (esp. p. 42)

archaeology deals 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; the techno-mathematical ratio electronically unfolds again as arche- or genotype, not simply historically distant. In electro-acoustics, harmonic oscillations, by virtue of the medium specifity 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"; Jules David Prown, "The Truth of Material Culture: History or Fiction", in: Steven Lubar / W. David Kingery (ed.), History from Things. Essays on Material Culture, Washington / London (Smithsonian Institution Press) 1993, 3: "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" - 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 ingineering 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 works of art: "the artist no longer directly touches or manipulates color, material, or objects. He or she manipulated algorithms, which are more or less abstract"[52] - which indeed required an artistic education beyond the traditional

[52] Abraham A. Moles, Introduction to the Colloquy [sc. *Computers and Visual Research*, Center for Culture and Information, August 3-4, 1968, Zagreb], reproduced 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)

Art Academy. Flusser defines photographic apparatus as "programming". Digital photography is "practically eternal; it is not subject to entropy, to the second principle of thermodynamics."[53] 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."[54]

- computational media defined by the fact they are not primarily the technology but formats. Former media like television or radio or the book, these are all being perceived more on more on the computer screen. And behind them is the software which defines these objects and enables these old media to return. Now how does museology display software? Software is a cultural document of our time, but how to preserve software?

Source-code based media art as software is 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 - but that's someone else's problem). Any latent 'bugs' subsequently revealed in the system are considere 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) depends 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[55]

- "The quality of the medium is of secondary importance, as long as the 'code' can still be decoded."[56] From that 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"[57].

- documentary science developed notion of "logical preservation"[58]. But any information must take place in or on a material support (storage medium),

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[53] Vilém Flusser, The Photograph as Post-Industrial Object. An Essay on the Ontological Standing of Photographs. In: Leonardo 19 (4), S. 329–332 (331)

[54] Jeff Rothenberg, Ensuring the Longevity of Digital Documents, in: Scientific American, Vol. 272, No. 1 (January 1995), 42-47 (42)

[55] See 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)

[56] 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)

[57] Gschwind 2006: 183

[58] 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)

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'."[59] But the metonomy which takes the Floppy Disc as a material support for the software itself is itself a hint to the material link. If past information is not just symbolically emulated but simulated, its temporal (entropic) behavior must be archivized 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. The well-known danger to cultural goods, physical entropy, in the logial sphere is replaced by a flat tempo(e)ality which is rather a logical state than a temporal ("thermic") object

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 actualized 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. So 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. If this is the task of a library or archive, in art museums, the physically located bitstream on the storage medium must be preserved as *raw images* for future analysis.[60]

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[59] Doron Swade, Preserving Software in an Object-Centered Culture, in: Higgs (ed.) 1998: 195-206 (195)

[60] Thorsten Ries, Die Geräte klüger als Ihre Besitzer. Philologische Durchblicke hinter die Schreibszene 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"[61], its adaption to new needs, its implemention 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

- past design for a media (art) piece can be time-delayed realized in the present. Charles Babbage's detailled 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."[62] But Babbage himself designed a "symbolic notation for his calculating machines which could be diagramatically "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.[63] "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."[64]

- techno-logical piece inherited from the past all of the sudden may become a piece of *futurum exactum*: "The logical replica embodies an inexhaustible set of predicates and can be interrogated in the light of unforseen enquiry in ways

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[61] Swade 1998: 195

[62] Quoted here after Bowden (ed.) 1971: 342 (Appendix)

[63] 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)

[64] Swade 2000: 146

that physical replica cannot."[65] Swade, with this ahistoric hermeneutics of the machine (since the diagram transcends the boundaries of the historical context), refers to the turingmachine 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."[66]

- different from an "action" painting by Pollock, for example, a piece of computer art is 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 can successfully present 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"[67] to fulfill its "enunciative function" (a term from Foucault's *Archaeology of Knowledge*) since software belongs to propositional logics itself. The "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 unforseen 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

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[65] Swade 2000: 144. See as well Klaus Wohlfarth, Zur Rekonstruktion der Z3, in: Wissenschaftliches Jahrbuch 1992/93, Deutsches Museum München 1993, 205 ff.

[66] Swade 2000: 146

[67] Doron Swade, Collecting Software: Preserving Information in an Object-Centred Culture, in: History and Computing Vol. 4 No 3 (1992), 206-210 (208)

game; it rather has to be inherently authentic, even on the subliminal level below human perception (the "formal materiality" as defined my Kirschenbaum[68]). Emulators "mimic the behaviour of hardware"[69], but true *mimesis* is co-originary (in a temporal sense beyond "history").

- contextual metadata may be recorded in unspaced bitstreams; still, there must be 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."[70]

- *different* from the familiar material artefact in museums, digital media artefacts in a dialectical synthesis combine what has been separated so far between historical and archaeological sciences: textual code and materiality. Since in its most literal sense techno/logy 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-enacment. 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"[71]. It has been a cryptographer (Ventris) who finally deciphered Linear B writing from Bronze age Greece.

- different from the familiar archaeological artefact, digital documents primarily consist 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[72] - since the computer is 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 is 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, could still be re-modeled by Derek de Solla Price.[73] Experimental archaeology of material cultural knowledge oscillates between implicit (latent) knowledge in terms of physical and

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68 Kirschenbaum 2008: 34
69 Rothenberg 1995: 47
70 Rothenberg 1995: 44
71 Rothenberg 1995: 47
72 Thorsten Ries, Die Geräte klüger als Ihre Besitzer. Philologische Durchblicke hinter die Schreibszene des Graphical User Interface, in: Editio 24 (2010), 149–199 (153)

mathematical self-evidence and "tacit knowledge" (Polanyi's undocumented social skills / *techné*).

Operative "dead" media collections

- for techno-epistemological analysis of media art, emphasis is 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

- operatitive preservation of media-archaeologically relevant objects (such as Peter Donhauser, Vienna, for his operative re-creation of the historic Bechtstein electronic piano, or Doron Swade, 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), require 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 become integrated as part of the activity of the operational media archaeology labs

- technical objects in "media" state / being only when in being 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

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[73] See Tony Freeth, The Antikythera Mechanism. Decoding an Ancient Greek Mystery (exhibition brochure), Whipple Museum of the History of Science, University of Cambridge, England, 2008

(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 sprang off from an error: "In December 1995 Vuk Cosic got a message, sent via anonymous mailer. Because of incompability 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"

- https://en.wikipedia.org/wiki/Vuk_%C4%86osi%C4%87 (accessed January 16, 2017) "graduated from Univerzitet u Beogradu (The university of Belgrade) and earned a BA in Archaeology in 1991" / "One of the pioneers of net.art, Ćosić became interested in ASCII code during a long period of research (1996–2001) 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. [...] One of his most recent works is the File Extinguisher, an online service that allows you to delete your 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 promarily with software." = Galloway 2004: 218 f. "As computers and network bandwidth improivged during the late 1990s, the porimary phsical reality that governed the aestehetic space of net.art began to fall away" = Galloway 2004: 220; the shift from media-archaeological aesthetics to content.

The Swiss initiative *Aktive Archive* (www.aktivearchive.ch) is 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, there is no "digital decay", since Boltzmann-entropy differs 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)[74]

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[74] See www.easylife,org/netart; catalogue: Timothy Druckrey / Peter Weibel (eds.), net condition, Camrbidge, Mass. 2000

- erasing records: A couple of artists have 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 has been done by the artists Blank & Jeron (Jodi)[75]

- Vera Kuni differentiating between technical emulation and "conceptual" emulation = 2007: 311 which results 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 is 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 displays 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.

- work will no longer functioned with current browsers; most external links will

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[75] See 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

have 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 musums 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). An advertizing 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)

Without new strategies for preservation many works of early Internet art will be lost to future generations. "Long term strategies must closely examine the nature of ephemeral art and identify core aspects of these works to preserve." Will the future experience these works as physical traces (hardware) or rather as coded documentation, or in its dialectiv 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 disapears."[76]

- collecting principle of the museum and storage principle of
computing belong 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 is 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 on oder to give access to it, in a newer format, say, or over the Internet?" = Ray Edmondson,

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[76] Brewster Kahle 1997: 83

AV archiving philosophy - the technical dimension, in: Proceedings of the IAMI-IASA Joint Anjual 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?"[77]

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

- EAS emulator service

- ISO file (often called an ISO image,) = 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: "An ISO file, often called an ISO image, is a 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

- strategy: take 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 custum computer software / OS / browser, unequal independent media (archaeological) art from scratch

- "Webrecorder" (free software, deposited on GutHub) allows 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 intalled on PC and Internet, as "performative archiving"

- moving image portals like Like YouTube; Internet itself has become the dynamic library of performative media art, autopoetically prolonging its tradition by countless data file copying and mirroring the operating system. But 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

[77] George Boston, lecture at IAMI/IASA Joint Annual Conference, Perugia 1996

providing contemporary users "a sense of their initial form" URL ??? - which is the phenomenological, human-oriented approach to preservation of media art. The media-archaeological alternative, by contrast, 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), 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 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 allows users to 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 aks 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"

CASE STUDIES

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 retained 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)

Really "forensic" media archaeology of an "archive" (the ROM)

- double task in museological preservation of media art: not just to preserve the aesthetic content but its cultural memory of the technological "condition of possibility" (Immanuel Kant) as well which made "media art" possible as art form in 20th / 21st century at all; artistic and aesthetic phenomena arising from a piece of media art mostly dissimulate their conditional techno-mathematical processing; "forensic" and "formal materialism" (in Kirschenbaum's sense) analyzes the critical techno-logical layers underneath, that is: the structure of its logical circuits and its digital codes. A media-archaeological understanding of early computer art is not nostalgic but has a techno-mathematical cutting edge, detecting.

- magnetically read out the bits which are latent in a ROM; this code is then put through the MAME *disassembler* and the remaining unknown bits figure out to make good code[78]

[78] See "Fun with masked ROM / Atmel MARC4", http://adamsblog.aperturelabs.com/2013/01/fun-with-masked-roms.html; accessed July 10th, 2014

- microchips and codes (hardware and software) both requiring analytic hacking (media art "criticism"). Software hacking is dangerous on the symbolical level, while tinkering with circuits that are directly connected to mains electricity is dangerous in a physical sense

- if algorithmic documentation lost, material criticism required, "[...] trying to do something like reset a fuse to allow reading/writing of protected areas or probe a data track to observe data being processed by the chip, or even trying to figure out the actual logic of a proprietary chip by viewing and reverse engineering it's construction"

- specific media-archaeological (or media-archival) target is the program code that is stored in a masked Read Only Memory (ROM) chip; if chip itself is using a known architecture and a known assembly language, "the only reverse engineering required is to recover the actual instructions stored in the ROM"; "forensic" philology of a masked RAM chip

- *semantic gap* opens when future observers (users) do not understand interface interaction of a piece of computer art any more.

- CD-ROM does not keep its data intact for a long time; machines themselves will become dated and be replaced by other systems in faster rhythms; therefore museum of algorithms is required.[79] If we consider the museum in terms of its traditional content which differentiates it from the library and the archive is the collection of material artefacts), these objects are surprisingly enduring. This quality should not be lost when museums are trying to be "digital" themselves. The discussion of the immaterial museum started with photography (André Malraux' *musée imaginaire*); Walter Benjamin was concerned that the photograph-based image collection could not be called "auratic" any more, since the technical reproduction loses the material basis of the traditional work of art. The materiality aspect completely shifts from the tight coupling of carrier (screen) and iconic surface (oil painting) to the electronic or computational image where the materiality is loosely (ephemrally) coupled to its visual signal output.

- "A medium is a large mass of loosely coupled elements, which is susceptible to form. [...] Within a medium, forms mark the difference between loose coupling and tight coupling"[80]; inbetween, coupled elements from different technical epoques, heterochronic (Simondon / Serres)

Re-enactment of *The Speaking Clock*

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[79] See Doron Swade, Collecting Software: Preserving Information in an Object-Centred Culture, in: History and Computing Vol. 4 No 3 (1992), 206-210; same author, 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

[80] Luhmann 1992: 30 f., referring to: Fritz Heider, Thing and Medium, in: Psychological Issues 1.3 (1959), 1-31

- several compatability layers (immanent "interfaces") within computers; translates previous operating system requests into the "language" (syntax) of new (WINE);triple stragety: 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 allows for a *non-historicist* form of preservation which is the co-originary re-creation of a hard- and software logic instead of the niqueness of its once individual implementation

- preservation of computer art not be 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 = 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

MEDIA ARCHAEOLOGY OF COMPUTING ARCHITECTURE

The digital temporalization *versus* the material endurance of architecture

- "architecture" refers a) to physical building materialities and b) to structural conditions, the *arché*; known from computing as well which is both symbolical code (software) and physical implementation to actually make it happen (hardware). The very term techno/logy reminds of this split ontology: both the regime of *logos* and of *techné*. "Technology" is not only the science of *techné* but the *logos* (in terms of algorithms) has been implemented in the material technique itself.

There are traditional paper-based archives of architecture. There have been proto-"digital" forms of transmitting architectural information for posterity: Alberti's "digital" transmission (tradition) of architectural urban memory by its radical sampling and quantifying into numbers in a Cartesian grid.[81]

- excess: digital archives of virtual architecture

[81] See Mario Carpo, "Descriptio urbis Romae". Ekphrasis geografica e cultura visuale all´alba della rivoluzione tipografica, in: Albertiana, Florenz (Olschki) vol. 1, no. 1 (1998), 111-132

- privileged affinity between architectural theory and technological media analysis, resulting in the quest for a *virtual museum* in the specifically computer-related sense of "computer architecture"

- Harold Innis developed his pre-"media theory" from research into the economical history of Canada such as fur trade. The "Carthage paradigm" (Canada, against "Rome" which is neighbouring American empire) stemmed from a privilege of transmission over storage, or rather: networking (naval trade routes in the case of Carthage), with "nodes" (ports) and *staples* which are intermediary storage. But the emphasis is on transfer, not (imperial) storage as expressed in monumental architecture meant to last for ever. Innis later differentiated between space- and time-"biased" empires. Canada would relate to the latter one, the US to the rather space-based Roman Empire. This allows for a direct a-historical short-circuit between Rome and ROM - the name for the imperial order within computing, the Read Only Memory chip.

- visualizing Internet data flows / visualizing high frequency e-trade: the *New York Stock Exchange (NYSE) Virtual Trading Floor and the NYSE Command Center designed between 1997 and 1999 by Asymptote Architecture (Hani Rashid and Lise Anne Couture)*; purpose of this virtual environment to visualize real-time numerical and statistical data, detect suspicious trading activity, and track the impact of global news events on the market. "The design's starting point was the existing physical trading floor, including abstracted virtual versions of the circular posts where traders were stationed. The real-time virtual environment returned to the physical world with the design and construction by Asymptote of the Advanced Trading Floor Command Center in the New York Stock Exchange"; high frequency trading, though, asks for a phenomenological interface to reveals its micro-temporal moment, which deserves different forms of becoming visualized or better: sonified, just like earthquake analysis is better done by audification, since the human ear is most attentive to micro-temporal changes (known from music listening)

- temporality of architecture is in its endurance. A building is not simply there but endures in the purest sense of temporality. It has been in the contect of kinetic art that the medium-spefificity of architecture has not been reduced to its rather static building material but by the "discursive" field (in the physical sense) of the energetic forces it truggles against - like wind pressure and, most of all, the Newtonean laws of gravity. In that sense every architectural material form is "neg-entropic" - while every articulation of "digital" architecture is entropic in the sense of Shannons information theory.

- architecture *lasting* (German: "lastet") not only in the material but as well in the temporal sense; in fact: time as channel is the slowness of "transmission" (storage); Heidegger, *Ursprung des Kunstswerks* (1936): "Die Schwere des Steins lastet"

- technical term from electro-engineering (and radio/antenna): "erden"

The *a-historical* temporality of virtual reconstructions of architecture

- notorious case of architectural reconstruction with computer-aided means: baroque Frauenkirche cathedral in Dresden which had collapsed in result of bombing in World War II and since remained a ruinous memorial. What has been called "archaeological reconstruction" by the resposible project leaders has since created the impression of time-reverse against the essential characteristic of historical time which is material entropy (architectural ruins). In Dresden, the so-called "archaeological reconstruction" was in fact a media-archaeological one: supported by IBM calculation, re-configuring the remaining building bricks and stones into the core of the reconstruction.

- most archaeological artifacts and buildings from the past in ruins - just like any archive primarily a set of gaps and absences

- "[...] computer-simulated rooms have established links, unities, and coherences wherever the factual state of the collection consists essentially of lacunae. / Now computer simulations may close up these gaps - say, in the famous IBM action of computer-projecting the ruins of the abbey church of Cluny as a virtual reality" = Friedrich Kittler, Museums on the Digital Frontier, in: Thomas Keenan (ed.), The End(s) of the Museum, Barcelona (Fondació Antoni Tápies) 1996, 67-80 (72 f.)

- while media anthropology mostly concerned with the phenomena displayed to human senses, a parallel reality at work which is hidden to the visitor - to be critically discovered by media archaeology (the algorithmic "subface" as opposed to "interface", in Frieder Nake's terms[82]. Analogous to Lacan's RSI triad: "[...] it also produces a data record that has never existed before. The ruin, beyond its imaginary completion, is also stored in symbols or algorithms. Each stone, whether preserved or simply presumed, has entered an objective structure" = archi(ve)-structure, "that makes it addressable according to its dimensins and characteristiscs. Each stone is both a fetchable data record an a fetchable procedure of its playback. [...] computer simulations do not merely form user interfaces, they actually constitute a museum. More precisely: a museum that, as in acient Alexandria, also functions as a library that has not gone through the modern split between texts and images, libraries and galleries."[83]

- overall impression of "virtualization", "digital architecture" in its material sense which nowadays encompasses a new class of architectural objects: the new micro-architectures of computing machinery, as expressed in the literal "von-Neumann architecture" as a term for storage programmability

- "adventure" computer games = passing through spaces; each room is being calculated as a function of source code; the architectonic signifier is a data type like "struct", consisting of diverse "static void" entries and values = archi-texture

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[82] Frieder Nake, Zeigen, Zeichnen und Zeichen. Der verschwundene Lichtgriffel, in: Hans-Dieter Hellige (Hg.), Mensch-Computer-Interface. Zur Geschichte und Zukunft der Computerbedienung, Bielefeld (transcript) 2008, 121-154

[83] Kittler 1996: 73

- beyond the trendy visual metaphors which compare the close-up photography of microchip circuits with the birds-eye view of a urban city

- museology of computer and computing *architectures* an escalation of the legendary exhibition *Les Immatériaux* curated by Jean-François Lyotard at the Centre Pompidou in Paris in 1985.[84] Lyotard conceptually started from the Indo-European linguistic root *mât* which means both measurement and construction, to unfold the different layers of the material (hardware) but as well the matrix (code) of "New Materials and Creation" (which has been the originally termed title of the exhibition). In spite of the immaterialities suggested by the final title, Lyotard insists that in a real museum exhibition nothing is more materially grounded that the seemingly immaterial objects on display = Jean-François Lytoard, After Six Months of Work ... (1984), in: Hui / Broeckmann (eds.) 2015: 25-66 (26). For an "immaterial" version see www.meson-press.com

- "The representation of the contemporary city is <...> no longer determined by a ceremonial opening of gates, by a ritual of processions and parades, nor by a succession of streets and avenues. From now on, urban architecture must deal with the advent of a 'technological space-time'. The access protocol of telematics replaces that of the doorway. The revolving door is succeeded by 'data banks', by new rites of passage of a technical culture masked by the immateriality of its components: its networks, highway systems and diverse reticulations whose threadds are no longer woven into the space of a constructed fabric but into the sequences of an imperceptible planning of time in which the interface man/machine replaces the façades of buildings and the surfaces of ground on which they stand" = Paul Virilio, Une vielle surexposée, in: Change International no. 1 (December 1983), 19-22; transl. "The Overexposed City", in: Zone 1-2, New York (Urzone) 1986, 540-550 (545)

- Virilio describing urbanism in a telematic society; finds parallel in computing architecture itself; radical update of the *Immatériaux* exhibition of 1985 will be an equally co-original display of computer architectures from within. Once the time-critical elements becomes essential for the very possibility of "virtual" architural "spaces" to emerge and exist, the term computer is to be replaced by computing, with an emphasis on the processual

- new kind of archival "tectonics" is the revelation of computer- and source code architectures itself; switch from computer-based representations of architecture to the architecture of digital computing

- *information architecture* behind the current forms of digital communication and Internet usage, consisting of several layers; such information needs to be archivized since it usually does not enter social and cultural memory on the discursive level

- term "tectonics" itself is known in archival science already but will be given a new meaning; on-line glossary of the Swiss Federal Archives: archive *tectonics* "[d]escribes the hierarchical structure of an archive's holdings. The Swiss Federal Archives contain various description levels: Main Departments (top

[84] See the exhibition catalogue *Inventaire*, Paris (Centre Pompidou) 1985

level), fonds, sub-fonds, series, dossiers and documents (lowest level). The archive plan search in Swiss Archives displays the archive tectonics in a hierarchical tree structure" = http://www.bar.admin.ch/archivgut/00941/01551/index.html?lang=en; access 28th July, 2014

Up-dating "Museums on the Digital Frontier"

- by-gone times when electronic computers themselves were "passable" - not as a didactic metaphor (like the giant computer once exhibited in The Computer Museum at Boston, Massachusetts, opened in 1979 and operated in three different locations until 1999; inter alia: The Walk-Through Computer, a two-story-high model of a personal computer, simulated to be working interactively: Giant working trackball used to control the World Traveler software. Inside the Walk-Through Computer: RAM on left, hard drive on right. Inside The Walk-Through Computer: microprocessor with electron microscope imagery of working circuits; ribbon cable and RAM in the background. The purpose of the exhibit was to show the anatomy of a computer and to explain how the various parts work and communicate with each other. Before entering the computer's chassis, visitors could roll a giant trackball to play "World Traveller" on the giant screen. Wall-sized graphics by David Macaulay and interactive exhibits explained how all kinds of information, from text, graphics, video, music, as well as computer programs can be represented as 1's and 0's. Inside the giant chassis, visitors walked between a wall-sized graphics card and memory card to the microprocessor, upon which a projected electron microscope imagery of a CPU's circuits in operation appeared. Further on, a RAM set of modules plugged into the motherboard included reveals showing electron microsope imagery of memory circuits, Peering into a mini-van sized hard drive, visitors could see read/write heads position themselves on either side of rotating platters. Richard Fowler was recruited from The Science Museum, London/Bradford, as exhibit designer. The exhibit garnered international publicity and more than doubled visitor traffic to the museum. " = https://en.wikipedia.org/wiki/The_Computer_Museum,_Boston#The_Walk-Through_Computer_.281990.2C_1995.29, accessed August 21, 2015

- three-dimensional computer (by necessity) can still be experienced *within* the UNIVAC computer in the Deutsches Museum, Munich; in age previous to Integrated Circuits, electronic components still three-dimensional.

- Friedrich Kittler's text: «Museums on the Digital Frontier», published in: Thomas Keenan (ed.), The End(s) of the Museum, Barcelona (Fundació Antoni Tàpies) 1996, 67-80: It is the structure of such techno-archives, and not their metaphorical (re-)presentation, which might become the real focus of an architectual museum; cp. Kittler 1996: 73. Open computer architecture: Z1 as re-built by Konrad Zuse for Deutsches Technikmuseum, Berlin; Technische Sammlung Dresden: Lehmann-Demonstrationscomputer mit verlangsamtem Takt. Hier leuchten die Glühlämpchen nicht metaphorisch, sondern sind zugleich die Speicher für ein Bit.

Digital Archivetextures

- media-archaeological approach to dis-cover the informational value from *within* the objects stored in an archive or museum:

 - such as histograms in image processing to calculate the entropy value of a (digitized) image (MA Wannhoff, p. 72)

- visual programming

- inbetween the classical museum (which might include computer history such as most museums of science) and the virtual museum as a function of computer simulation of architecture and CAD, the media-archaeological artifact: Computers from the early time of electronic and analog computing which where as big as rooms, thereby literally accessible such as the UNIVAC in the German Museum (Deutsches Museum) in Munich into which I have been once allowed to step in

- "launch of the PDP-1 (Programmed Data Processor-1) computer in 1959 marked a radical shift in the philosophy of computer design: it was the first commercial computer that focused on interaction with the user rather than the efficient use of computer cycles" = http://www.computerhistory.org; Zugriff 6-6-08

- less metaphoric "museum space" but navigation as operative diagramm (circuitry itself)

- "algorithm" in the context of computing implicitely refers not to the written code lines (like a musical "score") but to the hardware-implemented, executable algorithm, in computing architecture. In itself, an algorithm is just a mathematical notation which does nothing by itself. It has to be *read* - better by machines (the Turing Machine "tape reader") than by capacity-limited and slow human eyes. It has to be implemented into physical matter (the "computer" as artifact) in order to be gifted with time, to become processual in the time axis. The von-Neumann-*architecture* of computing is strictly sequential ("one bit at a time") and can only become *pseudo*-parallel

- concept *Museum der Algorithmen*; an understanding of "virtual architecture" resp. "algorithmic design" from its condition of possibility; media-archaeological "layers" of computing architecture; archival / algorithmic "tectonics"; think the digital archive from the computer architecture (both hard- and software; ModWikipedia / For example, at a high level, computer architecture may be concerned with how the central processing unit (CPU) acts and how it uses computer memory

- beyond physical architecture restrains: *n*-dimensionality

- ZKM media art installation *Legible City* by Scott not "legible" any more; re-enactment as problem of the "digital", better: algorithmic archive; Center of Digital Tradition (Codigt) at KIT (Karlsruhe); Gregor Vrachliotis at Faculty for Architecture

- in reverse of architecture becoming digital, the digital (which is a conceptual symbolic tool) becoming "architectural" by its implementation into hardware which brings it into the material world / into physical and informational time

- tempor(e)ality of digital works preservation from *within* computing systems