When the scholars run out of Latin, the magicians take the stage.
unknown

Georg Trogemann

Software and Magic
Or an attempt to re-enchant the world

Technical ignorance

Rationalisation through science and science-oriented technology has not resulted in people today knowing more about the conditions in which they live than those in the past. Rather, it only means that we could know more if we had the time and inclination to engage with it. As such, most of us do not know how the myriad of gadgets (mobile phones, fridges, ceramic hobs, electric cars, etc.) that we use as a matter of course every day actually work, nor how modern materials (building, raw, synthetic and adhesive materials) are produced, let alone how certain chemical substances (medicines, vaccines, drugs) take effect in our bodies. At most, we have a vague idea. However, we are convinced that there is no magic whatsoever at play and that there are in fact people who understand each respective principle at work quite precisely. It is the task of science to decipher things in the places where we do not yet understand phenomena. Max Weber already highlighted this paradox in our technological existence in a speech in 1919: "Thus the growing process of intellectualization and rationalization does not imply a growing understanding of the conditions under which we live. It means something quite different. It is the knowledge or the conviction that *if we wished* to understand them we *could* do so at any time. It means that in principle, then, we are not ruled by mysterious, unpredictable forces, but that, on the contrary, we can in principle *control everything by means of calculation*. That in turn means the disenchantment of the world."[1] An interesting question that Weber leaves unanswered is: Can we really know how things work, or do we only believe – as modern enlightened humans – that we have the potential to know it?

Trust in a better future through technological advancement – which characterised the whole of so-called "technocratic high modernity"[2] – is dwindling. Nonetheless, we are dependant on technical innovations to solve the climate crisis, which is itself a direct consequence of our highly technological way of life. Taking a closer look at informatics, we find what is probably the greatest promise of prosperity and progress since industrialisation hidden behind the keyword of "digitalisation." Nothing seems to be able to escape computation by algorithms. Even before "technocratic high modernity" – dated from 1880 to 1970 – began, the conviction grew amongst engineers that not only is technology itself subject to calculable principles, but also the invention of technology, which until then was governed by the magical moment of intuition, can be subjected to mathematical principles. In the 1840s, the engineer Robert Willis occupied himself with the development of mechanisms, that is mechanical constructions, with which any movement relationships between a number of fixed elements could be realised. He was convinced that there were better ways to achieve good mechanical solutions than leaving it down to the intuition of engineers, writing, "there appears no reason why the construction of a machine for a given purpose should not, like any usual problem, be so reduced to the dominion of the mathematician, as to enable him to obtain, by direct and certain methods, all the forms and arrangements that are applicable to the desired purpose, from which he may select a pleasure. At present, questions of this kind can only be solved by that species of intuition which long familiarity with a subject usually confers upon experienced persons, but which they are totally unable to communicate to others. When the mind of a mechanician is occupied with the contrivance of a machine, he must wait until, in the midst of his mediations, some happy combination presents himself to his mind

1 Max Weber, "Science as a Vocation," (1919) in: The Vocation Lectures, eds. David Owen and Tracy B. Strong, trans. Rodney Livingstone (Indiana IN: Hackett Publishing Company, Inc., 2004), 12–13. Weber compares the knowledge of his contemporaries with that of "Indians, Hottentots and savages." Problematic from today's perspective, but he does not value the knowledge of these groups any less than that of his listeners.

2 Uwe Fraunholz and Sylvia Wölfel, eds., Ingenieure in der technokratischen Hochmoderne, Cottbuser Studien zur Geschichte von Technik, Arbeit und Umwelt, Vol. 40. (Münster/New York: Waxmann Verlag, 2012), 9.

which may answer his purpose."[3] Without being called so, this is already the description of an algorithmic space of possibility that contains all of the solutions for a specific problem. Indeed, this is a very current perspective that we will return to later.

Today, we find ourselves in a situation in which we, depending on our occupation, might know the operating modes of the technology in our area, but no longer have a general understanding. In fact, this can no longer really exist due to the complexity of technical scientific knowledge. We are surrounded by a myriad of black boxes and all that is left to us is to trust that those we call experts have weighed up the risks and rewards of respective technologies for the common good. At times this goes wrong. In the first 50 years of the use of nuclear energy, there have already been two "beyond-design-basis" events, which – according to the experts – should only occur every 10,000 years at most. While our early ancestors were subjected to a nature that was wild and inexplicable, we largely have these historical dangers under control, we live in cultural landscapes where even the sighting of a single bear or wolf can trigger a major media event. What we now colloquially call wilderness only exists as a residue in protected reserves. In return we see ourselves increasingly exposed to the dangers of untamed technology that we do not understand. The philosopher Peter Sloterdijk thinks we are delusional if we understand early human societies as helpless. "In reality, modern human beings' range of competence has expanded so much that they are far more at risk of helplessness than prehistoric human beings. They are more often at risk of failing through incompetence, and on more fronts. Early humans, by contrast, benefitted from having a grasp of almost everything they needed for their personal and social sustenance, while they managed everything they lacked the skills for more or less routinely with the protection of rituals."[4] In this reading, magical rituals such as the recitation of a song for the weather god during a storm are an effective technique "to stay in good spirits in bad weather." Moreover, "magic is nothing other than the generation of optimism and the believed repulsion of damage and misfortune."[5]

3 Robert Willis, Principles of Mechanisms (London: John W. Parker, 1841), III-IV.
4 Peter Sloterdijk, "The Right Tool for Power: Observations on Design as Modernization of Competence," in: The Aesthetic Imperative (Cambridge and Malden: Polity Press, 2017).
5 Erhard Schüttpelz, "Magie und Technik," Zeitschrift für Kulturwissenschaften: Homo Faber, no. 2 (2018), 44–45, https://doi.org/10.25969/mediarep/13885

The belief that the world is – based on science – understandable and controllable and thus that our future can be shaped in key points is deeply implemented in our Western culture and is the most important motor of technological advancement. Thereby, perspectives other than prosperity and security achieved through technological progress are quite possible. Technical inventions open up new spaces of action and experience to us and in so doing something magical is also always in play. Clarke's third law – according to which any sufficiently advanced technology is indistinguishable from magic – is an adage well known far beyond the world of science fiction. The question of whether it is difficult to understand technology because today's knowledge can not be handled quantitatively, or because there are actual basic epistemic boundaries is not an easy one to answer. The latter would mean that the disenchantment of the world proclaimed by Max Weber is based on an error. With a view to algorithms and digital technologies, in the following an attempt will be made to at least deliver clues concerning why this question is so problematic. For some phenomena, the label *"magic"* may prove more fitting than "rational" or "causal," not only from the current perspective – because we have not yet understood it – but also in the long term.

The historical world view and digital technology

In an interview on the fringes of the series "AusZeit,"[6] organised by Vodafone Institut für Gesellschaft und Kommunikation Berlin in 2016, the literary scholar Hans Ulrich Gumbrecht spoke of the explosion of possibilities in thinking, planning and acting created by current electronic communication systems and computing power in general. However, the rapid growth in options through "the fusion of software and consciousness" brings not only increased freedom, but is also overwhelming for all of us. He often observes that his own children, who are in their mid twenties, need the whole of Thursday to choose from all of the options for Friday, Saturday and Sunday. Subsequently, when Friday, Saturday, Sunday comes, there is constant doubt: "can't we perhaps do something else or shouldn't we have done something else." It is his impression that the weekends often fail because, unlike in the past, there are so many possibilities.

6 Hans Ulrich Gumbrecht in conversation with David Deißner on the fringe of the series "AusZeit" in Cafe Einstein Stammhaus, Berlin 2016. Organised by Vodafone Institut für Gesellschaft und Kommunikation.

A quite plausible suspicion that with the objective increase in leisure time options, together with media networks constantly informing us about them, a subjective unease grows that the party is always happening somewhere else.[7] The problem is that choosing one of the alternatives eliminates all of the others. The vague promise that resides in the plurality of possibilities collapses in the moment of decision and the loss sustained increases with the size of the offer. This that means you can only make the wrong decision. Gumbrecht's observations – in which his polemic distance to digital technologies is also expressed – are part of a comprehensive diagnosis of the present. Under the term "chronotope," which targets our social and cultural constructions of temporality, he contrasts two different concepts of time: the chronotope of "historical time" – also called the "historical world view" – and the new chronotope of the "broad present," which according to his thesis has appeared since the second half of the 20th century. In the following, these two cultural concepts of time should help us achieve a better understanding of two different programming paradigms in digital media.

According to Gumbrecht, "historical time" is the specific chronotope that understands time as the necessary agent of change.[8] Gumbrecht believed that this understanding of time as a transcendental principle and effective power of change – which arose at the same time as the humanities – was so strongly institutionalised in Western culture between 1830 and 1980 that it was taken for the true über-historical concept of time, for time itself. Due to a lack of space I will not try to retrace his argumentation as to how we reached the formation of the still widely canonised historic world view, instead I limit myself in the following to a brief presentation of the essential features from his perspective.[9] It is first the world view from which we believe we can leave every worked-through past behind us and that its orientation value for the present fades, the further we leave it behind us. Second, it is the world view in which the future is an open horizon of possibilities to be shaped by us humans. Third, the present shrinks to a short, no longer perceptible moment of transition between the past that you leave behind you, and

7 Cf. Fear of Missing out (FOMO), accessed September 17, 2023, https://en.wikipedia.org/wiki/Fear_of_missing_out
8 Hans Ulrich Gumbrecht, "Zeitbegriffe in den Geisteswissenschaften heute," in: Zum Zeitbegriff in den Geisteswissenschaften, ed. Österreichische Akademie der Wissenschaften (Vienna, 2017), 6f.
9 Cf. Ibid. 9f.

the future, that is yet to be formed. Gumbrecht adds another two to these three perspectives adopted from historian Reinhart Koselleck. Fourth, the imperceptibly brief present becomes the epistemological place of the subject, that is the place "where people consciously adapt experiences of the past to the present and choose from the possibilities of the future on this basis, thus shaping the future,"[10] which we call "doing" since Max Weber. Fifth, we assume in the historical world view that time is a necessary agent of change and there are no phenomena that can evade change. Ultimately, it will always become apparent how a logical necessity is inherent in all changes. According to Gumbrecht, the historical world view was constitutive for the humanities as a whole because it co-emerged with it. Without this notion of time the philosophy of history or literature or art history would not have been possible, nor would capitalism or socialism, which have the necessity of an open future in common, be conceivable.

How does technology – especially informatics and digital technologies – behave with respect to this world view? Gumbrecht refers explicitly to the humanities with his diagnosis of two central concepts of time. For technology, the idea of progress, which accompanies the implementation of the rational world view and represents a guiding principle of modernity, is central. The idea of progress is also reliant on the notion of an open, shapable future as its inner driving force. While the production of meaning, comprehension, and interpretation are essential in the processing of the historical world view that the humanities undertake, for technology just as design, it is about doing, i.e. the production of material facts. Both humanities as well as technical sciences refer to the same linear time arrow, but they concentrate on different sections of the temporal axis, there the past, here the future. In technology it is not primarily about the valuation and interpretation of the present or past, but rather the poietic production of the future. Pragmatic realism is required for the design of the future to succeed, or as Robert Musil puts it, "To pass freely through open doors, it is necessary to respect the fact that they have solid frames."[11] Only technologies that pass the reality test are viable. Trivially, an invention is only an invention if it

10 Ibid. 10.
11 Robert Musil, The Man Without Qualities. trans. Sophie Wilkins (London: Picador, 1997).

also works, that is, it manages to stabilise material processes so that an intended functional behaviour sets in that is replicable at any time. Casual relationships and the overcoming of material obstacles are decisive factors here. The skills necessary for this are not exhausted in epistemic knowledge, it is much more that a new phenomenon is established that not only really exists as an object, but also whose production is communicable and teachable and whose use generates new patterns of action and habitualisation. Epistemic knowledge is needed especially in the developmental phase, which is still concerned with the control and consolidation of technical phenomena, and it increasingly disappears with the formation of habits. In this context, inventions are to be distinguished from innovations. In order to speak of a innovation, it is insufficient to present a technical novelty, but it must also be successfully implemented. It is innovations that ensure that technical products become obsolete and eventually disappear again from our social environment, until they ultimately belong to the museum of the technical past. One talks in this context of disruptive innovations when products radically change existing structures and whole markets within a short period. In the digital realm this has led to the explosive growth in possibilities of thinking, planning and acting described at the beginning. Therefore, fundamentally the historical world view, with its division into past, present, and future, whereby the present of the place of action and time are the operative principles behind all change, can also be easily identified as a formative background foil in the development of digital technologies.

This general picture is to be complemented in the following by three summaries specific to digital technologies.

Past: In the world of the computer, the past is identical to that which exists in the digital present. All data and algorithms stored at a certain moment belong to the past of this computer or network. That which escapes digitalisation simply does not exist and is thus neither past nor can it, through further computations, be part of the future. In order to maintain and optimise their own functioning and at the same time allow reasonable handling of the past and reconstruct incidents and processes in sufficient precision, digital systems permanently log their own operation. The question is then, which previous incidents can be reconstructed from this data and which future occurrences can be predicted. However, where there is no data, there is also no past. Storage technologies immediately split occurrences into two categories, the recorded and the not recorded past. From a forensic perspective it makes a difference whether data exists or not. If a mobile phone registers in a radio cell at a certain time, this certainly allows conclusions about occurrences outside the computer. How the data is connected with the world is also decisive. The integrated backup function of Mac computers is called, for quite obvious reasons, Time Machine. If data is accidentally deleted or the computer has a defect, the system can, at any time, be restored to an earlier state. The time between malfunction and the last backup no longer exists from the perspective of the computer. Generally speaking, only that which has left traces in the present, in the archives, nature, the heads of people or in the case of electronic media in the digital data, can become the past. This data can now be analysed, interpreted, and provided with sense and thereby also be used for the planning and forming of the future from ever new perspectives. This is not meant in the classical hermeneutical sense, but rather in an algorithmic sense. The meaning of data is identical with what the respective algorithm makes of it, very similar to the Wittgensteinian language game, where the meaning of a word is identical to its use in language.

Present: Digital processors are clocked, that means there are only defined states in the brief moments of synchronised standstill, of non-operation. Current processors are clocked with 2 to 3 GHz, so the system finds itself in a defined state 2 to 3 billion times in one second. During operation itself, the state of the processor is not defined. The present of the computer is made up of those tiny moments between the individual steps of computation. In every second, billions of tiny pasts are thus created. Depending on the executed operation, the system accesses stored data, pasts of the system from long ago, and creates the successor state according to deterministic rules. Here nothing is left to chance. The mechanism of the clock signal is developed precisely to eliminate uncontrollable physical variations and thus sources of ambiguity, which in theory limit the precision of computation in unclocked analogue computers. What we call digital is realised on the undermost level of circuits. The quick sequence of discreet presents does not allow ambiguities or scope for interpretation, it is a mono-perspectival system. In the theory of informatics, there is a special class of machines in the finite automata that know no past. The next state depends here exclusively on the momentary state of the machine, no earlier values flow into the calculation. When the system finds itself in a certain state, the way this state was reached plays no role for the future of the system. All of the past is thus irrelevant. It is easy to show that finite automata are a sleek and powerful concept, but that they do not achieve the computational power of automata with memory (e.g. Turing machine, pushdown automaton), which can access prior incidents.

Future: One might think that the future of computational processes can hide no surprises. After all, we already know from the algorithm, in the greatest possible accuracy, the steps that the system will execute in the future and each one of which runs completely deterministically. In interactive uses, where external agents intervene in computation, the form of intervention is already anticipated and the reaction to it defined in the algorithm. In many cases, the behaviour of computation processes can indeed be predicted through an exact inspection of the programme text that codes the algorithm. However, algorithms can just as easily be written that, despite being only made up of a few lines, are opaque or about which certain principle statements can not be made at all. One can also ask questions of algorithms that are difficult or impossible to answer in the code itself. For one class of algorithms, the halting problem, the question, of whether the computation reaches an end or not, is only partially determinable, so only by letting the algorithm run. Decisive here is that there is a qualitative difference between the written algorithm – the programme code – and the process of its execution. In this context chaotic (non-linear) dynamics that show a special sensitivity to the initial conditions are also interesting. Many laws of nature – for example – can be formulated as differential equations and simulated with a computer. Predictions about the future behaviour of the system can then be made based on this model. However, the long-term development of these systems over time is not predictable, although the underlying equations are often very simple and completely deterministic. If the identical model (programme) is run on two different computers, even the word length of the computer used can decisively influence prediction results. Even from these brief observations on predicting the future behaviour of algorithms it should be clear that algorithms have a difficult relationship with questions of prognosis.

The broad present

> *But if there is such a thing as a sense of reality – and no one will doubt that it has its raison d'être – then there must also be something that one can call a sense of possibility.*
> *Anyone possessing it does not say, for instance: Here this or that has happened, will happen, must happen. He uses his imagination and says: Here such and such might, should or ought to happen. And if he is told that something is the way it is, then he thinks: Well, it could probably just as easily be some other way. So the sense of possibility might be defined outright as the capacity to think how everything could 'just as easily' be, and to attach no more importance to what is than to what is not.*[12]

According to Gumbrecht's conviction, we have "for a long time, lived our daily lives under a social construction of time that has nothing to do with the historical world view. […] In this other world view, which, I think, dominates global everyday life today, the future is in no way an open horizon of possibilities that we can shape, but rather one filled with dangers that seem to head towards us inexorably. Global warming, for example, the end of resource reserves, demographic development."[13] Through globalisation and not least due to electronic storage and communication media, the past is also not a dimension that we can understand, work through and leave behind us in this new understanding of time. From his perspective, the past permanently floods the present, which is now no longer an infinitely brief moment of transition, but rather a widening present of simultaneities. While the brief present of the historical world view, in the sense of the Cartesian "cogito, ergo sum," was self-referential and related to consciousness, we will now endeavour to incorporate sensuality and the body back into our self-reference. In the broad present, time has lost its former directionality, so we are constantly active and permanently in a state of transmission and reception, in multitasking mode, yet this hectic state no longer develops dynamism in terms of a change of circumstances. "In any case, this present becomes a universe

12 Ibid.
13 Gumbrecht 2017, 11f.

of contingency, an endless range of perspectives and possibilities. Which implies incredible amounts of freedom, but perhaps will also become an existential overload for us as individuals."[14] Because the broad present includes everything and all of the past is cancelled within it, according to Gumbrecht, it does not lead to the displacement of the historical world view but rather a parallel existence.

Following Gumbrecht's argumentation, the broad present dominates global daily life, in the historical sciences as well as the technical sciences, which are in turn inextricably entangled with politics and economy, but the historical chronotope still reigns. From what I can observe, especially regarding the uncontrollable, risky future, such as aforementioned climate change, there is now an even greater concentration of scientific and socio-political efforts aimed at keeping negative impacts in the future as minimal as possible. Research areas such as speculative design, which primarily deals with speculative futures and strives for the expansion of (also unreal) spaces of possibility, sees itself exposed to keen criticism in light of urgent problems. The drafting of new collective world views and patterns of behaviour, which mean a quicker and tangible change in everyday life, is currently at the centre of design interest. Here we can see a concurrence of chronotopes rather than the replacement of one by the other. The more that one tries to understand Gumbrecht's chronotopes, the greater the doubt concerning whether this proposal really clarifies the current situation. However, whether his diagnosis strikes at the core of our present social condition is not at all decisive for the following considerations. Not only are his chronotopes suitable for characterising two historical world views, but they can also help to illustrate two fundamentally different views on algorithms. One can also use these different perceptions of time and the handling of scopes of possibility to look at the development of software.

I would like to call the default setting that underlies professional software development to this day the Chronos paradigm. Here the development of software takes place in a more or less standardised framework so that the complexity of processes is kept manageable. All of the common procedure models of engineering application

14 Ibid. 12.

development today belong to this paradigm. In order to retain control over the development process, it is divided into manageable units, limited in terms of time and content. The Chronos paradigm also strictly follows the guiding principles of a disenchanted world outlined by Max Weber. Everything is computable or is made computable, nothing can permanently evade the grasp of the algorithm. The focus is the targeted solution of problems. All effort is geared towards the future, progress, and the improvement of products. In this, actors follow the conviction that what they are dealing with is, in principle, understandable, controllable, and ultimately also computable. This begins with the specification sheet, which already tightly defines the aim. Considerable energy is invested in planning to maintain control and assure the achievement of the predefined result. Realisation takes place on a deterministic machine, whose overall behaviour stems from the controlled succession of precisely defined elementary steps (operations). Computing and understanding are largely seen as the same here. It is about causal thinking and the juxtaposition of possibilities, i.e. Robert Musil's realism dominates events.

The software philosophy that I will call the Kairos paradigm follows a fundamentally different objective. It is no longer about evaluating the initial situation and enforcing desirable conditions in the future through suitable actions in the present, but rather about giving up control and thus gaining freedom. More precisely, it is about the production of scopes of possibility in which something new can occur. It is not the sense of reality that is central here, but rather the sense of possibility. Instead of cybernetic control, i.e. the targeted control of a predefined result, it is about a lucky discovery. Just as for Musil the sense of reality and the sense of possibility are not a statement about the structure of the world, but rather only that it can be encountered with different attitudes which accordingly leads to different results, Chronos and Kairos philosophy in programming say nothing about the basic structure of the digital computer. In the Kairos take, in line with the myth around Kairos, it is about recognising opportunities at the right moment and grabbing onto them. However, in order for favourable opportunities to arise, the digital spaces of possibility for it must first be produced by software. The creation and growth of possibilities are not seen here, as with

Gumbrecht, as a problem, but rather as an essential prerequisite to escape the disenchanted world. Overwhelming through surplus is a condition of success here. However, abstract spaces of possibility in the memory of a computer are not yet phenomena. Possibilities must present themselves to the senses, they have to be made observable and perceptible. Here it becomes clear that perceptions, occurrences, and experiences always depend on perspective, of which there are potentially an infinite amount. Therefore, in media generated phenomena, two ways of appropriating the world always interact: appropriation through concepts – through symbols and abstraction – and adoption through the senses and the body. Computer scientists normally prefer the former, artists the latter.
Yet another problem presents itself alongside the question of how digital spaces of possibility are to be constructed. We must decide how we wish to use this approach to escape the "loss of materiality" that forms the actual centre of Gumbrecht's time diagnosis. The disenchantment of the world is not least a result of excessive abstraction. The character of digital media is to reduce the whole world to a play of symbols. The world of programmers is largely made up of their skilful movement through hierarchical layers of symbol systems and formal structures. In coding in particular this means a short-circuit of consciousness and software and the complete exclusion of the outside world. What Gumbrecht calls "presence," so spatial proximity and substance, lapses almost completely. In line with the idea of re-enchantment, we must also question which fundamental potential connections between software and the world can be realised and how physicality and concrete physical materiality can be brought back into play. Before we look closer at how the Kairos paradigm can answer these questions, we should clarify the conditions under which one can even talk of re-enchantment – namely magic in technology – in further detail.

Magic and technology

> *Magic is objectification within an order that is felt as objective and assumed as objective. That this order seems to foreigners and outsiders as, in part, imagination, has nothing to do with this precondition of objectivity, as our objectivities and their legitimations too, presented in absolute conviction, already appear as subjectivities within a few decades.*[15]

Magic claims to be able to achieve supernatural effects through more or less ritualised actions. In contrast to technological action, a special ability that is not widely accessible is required. The literature on the topic of magic is vast and the current article can in no way do it justice. I will therefore limit myself to the presentation of a few aspects that seem to me as sufficient justification for the use of the term in the title of the article. First, I wish to name – with close reference to Markus Walther – some similarities in the patterns of action of magic and technology.[16] The first important feature is that in both cases it is about action that pursues a purpose, that is not performed as an end in itself, like the playing of a musical instrument. Both magic and technology have genuine poietical character, they are about the attainment of very worldly aims, like the provision of material goods, power, prosperity, fertility etc. Both also strive for the expansion of the effectiveness of human action. For the layperson, the aims initially appear unachievable, yet the actors in both cases manage to acquire control and certainty over the objective. However, in this it is important that binding patterns of action are followed. The processes are strictly regulated, the individual steps are to be carried out carefully and precisely. Failure to comply leads to the desired outcome not being achieved or only being unsatisfactorily achieved. Both the magician and the technician are faced with scepticism from society, as we do not know how they accomplish their work. Each requires special skills and we fear the negative consequences in both cases. Summarising, according to Walther, it is about "action that is expertise-needy, rational-outcome oriented and control desiring."[17] Parallels between the two practices certainly present themselves to the outside observer. This poses the question of how we can differentiate technological and magical efficacy with certainty.

15 Schüttpelz, 2018, 44–45. DOI: https://doi.org/10.25969/mediarep/13885.
16 Cf. Markus Walther, "Magie und Technik: Parallele Denkungsarten?" accessed September 6, 2023, https://www.vergleichende-mythologie.de/magie-und-technik-parallele-denkungsarten/.
17 Ibid.

Comprehension can provide a key to such a distinction. In the classical division, technology follows a rational paradigm of cause and effect, while magic goes beyond the laws of nature and can no longer be explained by reason. However, magical actions also follow causal ideas. Ninian Smart distinguishes between "devic" and "mantric" causality models to explain the connection between ritual acts and the results obtained.[18] In the devic model, the agent turns to a god who is to be appeased, in the mantric model, on the other hand, the action itself brings about the result. However, everyone knows there is no relying on gods. The more reliably the ritual works subjectively, the more pronounced its mantric character. Whether the underlying causality also exists from a scientific perspective is irrelevant, the subjective conviction that the ritual works is decisive. In the default scientific view, magic is an illusion, subjective and not in accordance with the facts, while technology is based on objective laws, which apply independently of the specific actor. However, according to Schüttpelz, who in turn follows Marcel Mauss and Claude Lévi-Strauss in his account, the attribution of objectivity and subjectivity to magic and technology can also be thought of inversely. "Technology is a subjective effect on the world that remains and becomes aware of its subjectivity, i.e. its own volitional acts, its own capriciousness and the arbitrariness and human evoked artificiality. Magic, on the other hand, understands itself, due to its cosmological foundation, as an intervention on an objective basis. Magic refers to how the world is built up and it integrates itself in this structure. Therefore, in most cases, we can not speak of a striven for intervention, rather a self-integration, a non-intervention or a conscious objectivisation of its own action."[19] Indeed, as Schüttpelz also highlights, the notion of technology as a subjective impact on the world, which is subject to a decent amount of capriciousness, fits better to the traditional European view of technology. The "techné" of antiquity was about the formation of subjective und intersubjective skills and not one "theoria" or scientific objectivity absolved of its usefulness. The form of reason of "techné" is "poiesis," not "theoria." Technological actions are arbitrary insofar as the decision as to which technologies are developed and which purpose they serve is made subjectively or intersubjectively and does

18 Ninian Smart, *Dimension of the Sacred. An Anatomy of World's Beliefs* (University of California Press, 1999).
19 Schüttpelz 2018, 45.

not stem directly from realisable possibilities. Technology is always part of the open future horizon that we can shape.

We can pick up here and go deeper to separate technical and magical efficacy precisely. For this purpose, it is important to identify which knowledge and which concept of truth is at work in technology, or rather poietic action. In my view, the philosophical theory of pragmatism, which measures the value of a theory on the practical uses and consequences it yields, provides the most convincing explanation here. Classic American pragmatism also assumes that all theoretical knowledge arises from practical interaction with things and is fundamentally fallible, whereby rationalistic ultimate justifications are rejected. According to William James, in pragmatism, agreement with reality "means verifiability. Verifiability means ability to guide us prosperously through experience."[20] In this context, truth is nothing more than a collective term for verification processes and is created in the course of experience.[21] In this sense, technological development processes are permanent verifications of theories. As long as everything goes well, i.e. everything goes as expected, this confirms the underlying theoretical notions. Only when something unexpected happens, things no longer work as they should, do the ways of thinking that guide action also become questionable. The most important function of theory in technology is that it expands the framework of action and allows predictions even in changed conditions. Theories are feats of abstraction, that means the superfluous is left out and the matter is reduced to the main variables. Successful abstractions therefore enable very different situations in practise to refer back to the same principle. It is this variability in science-led technical thinking that makes it possible, in combination with practical experiences, to make statements about expected behaviour and thus develop the engineer's massive range of action. It is not a question of whether the theory used corresponds with reality or eternal, definitive truths. As Hans Vaihinger already identified in 1877 in his philosophical postdoctoral thesis *Logische Untersuchungen. I. Teil: Die Lehre von der wissenschaftlichen Fiktion* (Logical Investigations. Part 1: The teaching of scientific fiction), science always works with false assumptions and ideas, which he

20 William James, *Pragmatism: A New Name for Some Old Ways of Thinking* (1907), (Project Gutenberg EBook, 2004), accessed September 06, 2023, https://www.gutenberg.org/files/5116/5116-h/5116-h.htm.
21 Cf. Ibid.

calls fictions. For Vaihinger, fictions are notions that we know are not durable and for which we can find no representative in reality; for example, our notion of atoms. However, in his philosophy of "as if," it is not about freeing oneself from these consciously false ideas, but rather recognising the necessity of these fictions and understanding them as tools that enable thinking in the first place and working with them. This is a useful characterisation of the function of theory, especially for technology and technical action. For example, fire can be ignited in different ways. Regardless which method we choose, we must master the necessary movements. Those lucky enough to own a lighter can reduce the act to a short movement of the thumb, while the remaining knowledge about fire as a chemical process is built into the lighter. The methods of making fire as a goal-oriented act are learnable and communicable and one does not need to know all of the chemical-physical processes involved. At the same time, when action is concentrated on an objective, the side effects slip out of view. The effects on our ancestors of being able to control fire were considerable and certainly not planned for intentionally. The preparation of food changed completely, the heat killed bacteria and parasites, fire offered protection from animals and had a social function as a meeting place. Not least the change in diet prepared the ground for the growth of the brain etc. The practical knowledge needed to produce an artefact and the knowledge we need to understand the effects and the significance of the artefact within its use context are completely different. Being able to do something does not mean fully understanding it at the same time. In short, technology is poietic in its basic structure, it is primarily about doing, not about propositional knowledge, sense, or understanding. Theory plays a role in production insofar as it helps to generate new ideas for technological developments, guide the technical process and achieve the desired results.

So much for the general relationship between technology and magic. One can thus only talk of magic in the context of digital technologies where there are fundamental gaps in explanation. Therefore, where phenomena occur that are quite reliably reproducible, but which are not understood. To this end we must first briefly recall the basis of the digital computer. The foundations on which the whole construct of the digital is built are abstract symbols and operations.

Both are realised by the electronic hardware, which programmers do not need to worry about, as their thinking starts at the symbolic level. This symbolic machine construct has its origin in mathematics, which had shown that two symbols and a few basic operations is sufficient to produce every structure that is realisable with symbols. The necessary elementary operations are simple and easy to understand by anyone. In order to understand the complex play of symbols, it is decisive that both the operands (the symbols that are processed), as well as the operators (the rules according to which the operands are transformed) are coded in the same repertoire of symbols (0 and 1). The symbols themselves only mark out differences that allow distinctions to be made, otherwise they are empty. In fact, we must now comprehend this construct of operands and operators, that is completely deterministically defined and is occupied by no further prior meaning, as an autonomous system, far beyond mathematics in its potency. Only when we recognise this very particular reality of the digital can we understand how it was able to unfurl such power over the past decades. Numerous further layers of symbolic systems are realised on the electronically realised calculation of the undermost layer, which is only made up of two symbols and a few deterministic operations, whereby the connection between the layers is in turn realised by symbolic systems (general transformations, e.g. compiler or interpreter). The most important symbolic layer in this hierarchy for the continuing development of uses are higher programming languages, which provide not only complex data and control structures, but also programme libraries for the programmers. Therefore, we are dealing with a complex configuration of interlaced symbolic systems, in which constant chiastic switches between operators and operands take place. What is an operator in one model, is treated as an operand by other models, and so on. At the same time, we can integrate the most varied of connections to the outside world in this play of symbols. Only through these connections with the world are the meaning of symbols realised.

Where should explanation gaps open up and phenomena arise that we can fundamentally no longer understand in this complex but, in general, strictly deterministic play of symbols? In fact, several principles can be identified that stubbornly resist the understanding of programmers. Here it is also of little use to refer to the fact that technology follows a rational paradigm and that it is the duty of the programmer to understand what they are doing. Programmers are clearly the authors of that which arises and the processes follow deterministic rules, yet the result is surprising and only to be evaluated by letting the programme run. The causes of these obstacles to understanding are simultaneously the basic characteristics of algorithms:

Interlaced operations within a level: even the simplest of rules can, with variables that have strong interdependency, create very complex behaviours. This was already the central theme of Stephen Wolfram's 2002 book *A New Kind of Science.*[22] The core theses for Wolfram are: 1) the nature of computation can only be experimentally explored; and 2) the results of these experiments are of general importance for the understanding of the physical world. The impenetrability here is a consequence of dependencies between the operands (data). As the following example class shows, operators can also be included in the game. There is a qualitative, insurmountable difference between the rules and the process that defines the rules.

Change of perspective or level: The hallmark of *"evolutionary algorithms"* is that they abstract the biological basis of evolution, in which individuals arise through mutations over many generations and those which are viable in their respective environment reproduce. For example, in "genetic programming," which also belongs to this algorithm class, programmes develop other programmes. Many instances of further programmes are created at random from one programme. The generated programmes are only operands from the perspective of the generating programme. However, the generated instances are then run to determine their performance, namely how well they solve the predefined problem. In this "environment," in which they must prove themselves, they are also active as operators. Only the most successful programmes are chosen for mutations and for the creation of the following generation. Which programme codes arise after a series of generations is completely unpredictable. The most varied of methods of "machine learning" (neuronal networks, reinforcement learning, evolutionary algorithms, genetic programming) can be assigned to this area of changing perspectives

22 Cf. Stephen Wolfram, *A New Kind of Science* (Wolfram Media, 2002), accessed September 9, 2023, https://www.wolframscience.com/nks/.

or levels. A hallmark here is the chiastic operator-operand switch, that takes place between the programme modules involved.

Connections to the outside world: As long as we remain on the level of symbol and symbolic systems, we can only observe their formal structures. However, as soon as the outcome is materialised as a sensual perception offer for the user (as an image on a plotter, screen, as sound in a speaker, as the movement of a robot arm etc.), a further semantic hole appears, which can not be closed causally. Frieder Nake speaks here of the unavoidable double existence of computer objects, which he calls, in the case of digital images, undersurface and surface.[23] The surface is the image that shows itself to the user, the undersurface is its digital representation in the computer. The meaning of the surface of the image is an individual and singular interpretation of the viewer. “In the interpretative power of a person, the whole culture that they belong to takes effect in an opaque and certainly non-causal way.”[24] This view can be generalised regarding the connections between technology and the living environment of the user. The post-phenomenology of the American philosopher Don Ihde thus concentrates on the question of how technology influences the relationship between human and world, in others words how it structures our experience and self-image.[25] This approach, which is currently being intensively discussed and developed by an international scientific community, is also vitally important to our thinking here. The – in itself – meaningless play of symbols in the computer connects here with the body and the senses and intervenes deeply in the experiences and the self-image of the subject. “Humans and the world they experience are the products of technical mediation, not just the poles between which the mediation plays itself out.”[26]

Another term – albeit no less controversial than magic – which is capable of characterising the three areas of explanation gaps, despite all their variety, is emergence. One talks of emergence when new properties appear in a system that emerge from the

23 Cf., Frieder Nake, “Zeigen, Zeichnen und Zeichen. Der verschwundene Lichtgriffel,” in Mensch-Computer-Interface: Zur Geschichte und Zukunft der Computerbedienung, ed. Hans Dieter Hellige (Bielefeld: transcript Verlag, 2008), 121– 154.

24 Ibid. 126

25 Cf., Don Ihde, *Technology and the Lifeworld. From Garden to Earth* (Bloomington: Indiana University Press, 1990).

26 Peter-Paul Verbeek, *What Things Do. Philosophical Reflections on Technology, Agency, and Design* (University Park: Pennsylvania State University Press, 2005).

interaction of its elements. The emergent properties of systems are direct consequences of interaction (e.g. the local rules of a cellular automaton), but they can not be explained through analysis of the individual elements. Emergence research distinguishes between weak and strong emergence. While weak emergence emanates from a provisional non-explainability of the rules, strong emergence means that the explanation gap is of a principal nature. However, in practise the epistemic gap between macro phenomena and elementary operations is often so great that the distinction between weak and strong emergence is simply irrelevant. Emergence is generally understood as a property of systems, so it is concerned with the structure of the world and is therefore an ontological term. As such, the question of how far the concept leads to an epistemological or phenomenological interpretation remains. The emergence concept, as I would like to use it, should in any case include the senses, body, qualia, and phenomenological human-technology relations. From a post-phenomenological perspective (third area: connections to the outside world), characteristics do not emerge within a system and appear as phenomena of a higher level, but rather between linked systems. Bearing in mind the associated difficulties, the – at least provisional – core of the magic of computation can form an emergence concept that is generally understood and simultaneously adapted to the situation of digital computers and their programming. However, referencing back to the emergence concept, shaped by science, always implies a demand to understand and reasonably justify the principles behind phenomena. If one wishes, on the other hand, as sketched out in the next section, to generate new sensory phenomena and perception offers and stage them, "magic" seems better suited as an adjective. Magic in the sense of the above characterisation, as an intervention on an objective basis that accepts how the world is made up and integrates itself in this structure. Whereby the scope of possibility of that which can happen is itself created beforehand. However, what shows itself is not forced but rather found.

The Kairos paradigm: Programming in art and design

> *'The ethical imperative: Act always so as to increase the number of choices.' And, 'The aesthetical imperative: If you desire to see, learn how to act.'*[27]

In a technology oriented towards progress, the development of software is also completely subject to the rational paradigm. It is about the production of planned functionalities and properties, economic considerations of efficiency and market potential and not least reliability and security. The latter includes the obligation to understand how programmes work and their effects, and predict which dangers they open up. Software development as an engineering discipline cannot forgo these objectives, as uses are developed under rational and normative aspects. No one wants to board unreliable aircraft or use insecure online-banking. The behaviour of software must be predictable and secure for every conceivable situation. However, parallel to this, the de-rationalisation, aesthetisation and emotionalisation of software has long been expedited by design and marketing. This is not only evident in advertising for software products, such as computer games. The idea of the creative expression of the user is generally forefront in digital, social medias. According to Andreas Reckwitz, growing aesthetisation is one of the main characteristics of modern capitalist society.

> *In the context of digital culture – especially with the help of mobile devices like the smartphone – the late-modern subject is constantly surrounded by global streams of symbols and images that are on hand for functional but especially also aesthetic use. In this, the computer and Internet user is an activated subject: they create text and images themselves, for example in social media, and thus become cultural-aesthetic performers online. The possibilities of the computer simultaneously transforms creative and design work as well as cooperation between producers and consumers. Computer games and digital photography contribute to the training of new forms of an aesthetic sense of play.*[28]

However, the attempt by "cultural-aesthetic performers" to create individual styles from media set pieces should not be confused with the creation and exploration of experimental spaces of experience suggested here. Consequently, the Kairos paradigm offers not only

27 Heinz von Foerster, *Understanding Understanding. Essays on Cybernetics and Cognition* (New York: Springer-Verlag, 2003), 303.
28 Andreas Reckwitz, *Kreativität und soziale Praxis. Studien zur Sozial- und Gesellschaftstheorie* (Bielefeld: transcript Verlag, 2016), 238.

a new experimental system for art and design, it is also to be understood as a call to take a critical position on the current aesthetic practices of the digital; for example, the use of creative artificial intelligence apps in social media.

Chronos and Kairos programming are two completely different modes of dealing with the unknown. Chronos programming desires understanding, security and predictability, so avoids everything unknown. Kairos programming, on the other hand, needs the unknown, it creates open spaces of action and searches for surprise and aesthetic experience within them. We wish finally, by way of a few examples, to at least suggest how the Kairos paradigm can build on the deterministic layers of the computers made available by the Chronos paradigm to generate the openness required. While Gumbrecht, as described above, sees the exploding possibilities via digital technologies in broad modernity as overwhelming, they are prerequisite for aesthetic action in the Kairos paradigm. Key to this are digital spaces of possibility.

"The Library of Babel"[29] is a story by Argentinian author Jorge Luis Borges from 1941. In it he describes a universe of hexagonal galleries which serve solely the storage and research of books. The infinite library seems to contain all possible combinations of books of a certain size (410 pages, 80 letters per line, 40 lines per page). Borges explains how the librarians explore this world of books and try to find sense in them. Even the discovery of singular coherent sentences within the text would already require a great deal of luck. Our universe ($\approx 10^{80}$ atoms) is too small to materially realise the $25^{1,320,000}$ books in the library of Babel. In order to create a book of 410 pages, 80 letters per line, 40 lines per page as a digital object, one can use a data structure of 1,320,000 symbols of the type "character." Once the data structure is laid out, the algorithm to generate the whole library, book for book, is made up of just a few lines of programme. Every single book can also be addressed and completely read. If one intends to write a book of 410 pages, there are two possibilities. In the Chronos paradigm you write the book yourself and thus keep control over every single word. In the Kairos paradigm, you only have to find the book, which already has its location (address) in the

29 Jorge Luis Borges, "La Biblioteca de Babel," in El jardín de senderos que se bifurcan (Buenos Aires: Editorial Sur, 1941) and Ficciones (Buenos Aires: Editorial Sur, 1944).

digital version of the library of Babel. If the books are arrayed completely at random, the chances of finding the book that one would have liked to have written are very slight. Therefore, the art is to construct the scope of possibility in such a way that all books that could be interesting from a certain perspective are close to each other or form their own subspaces in which uninteresting books are not even represented. On the other hand, of course, movement through the library could also be organised algorithmically in such a way that the probability of finding the right book on your travels is very high. The Kairos paradigm only comes into its own if I make a surprising discovery in line with the serendipity principle, namely if I find something that I was not even looking for through a happy coincidence.

Not only the space of possibility of texts, but also that of digital images is easy to describe on a software level. An image here is a simple two-dimensional field of pixels, each of which in turn is made up of three values for the three colour channels. Equally, the spaces of possibility of sounds or movements in space can be very simply realised in higher programming language. It is in the nature of the digital that whenever one lays out data structures (for image, text, sound, etc.) as variables, the whole scope of possibility of this data structure is also thus defined. As the example of the library of Babel shows, even relatively small data structures have such huge scopes of possibility that it is simply impossible to have all instances, that is the specific realisations of data objects, generated and shown. If we look at programming from this perspective, then algorithms are strategies for creating spaces of possibility and navigating in them. Uninteresting instances can either be already excluded at the construction of these spaces or avoided in the navigation through them. Artificial neuronal networks are also so successful because it is possible to automatically generate very efficient representations for text (text encoders) and images (image encoders) with the help of learning methods. So-called “latent spaces” are spaces of features or embedding, in which multitudes of objects are depicted in mathematic diversity in such a way that objects that are similar are close to one another. Latent spaces are, as a rule, adjusted by machine learning, whereby their interpretation is very difficult due to the explanation gaps of the algorithm described above. For example, the learning methods to represent words in a text by high-dimensional vectors of real numbers are also called "word embeddings." Here the encoders and decoders realise the semantic connections to the outside world. As the digital representations for both text as well as for pictures are high-dimensional, real-value vector spaces, images and texts can then be relatively easily – for example, via spacing – placed in relation to one another. From the various modules for various purposes (for example, automatised image complementation, up-scaling, down-scaling, text-to-image and image-to-text), new experimental media spaces can be realised through alternating and iterated connection of these modules. Such configurations of artificial neuronal networks are simultaneously digital representatives of the broad present in line with Gumbrecht. Experimental media spaces are produced based on the whole spectrum of cultural products, at least as far as these are digitalised. In these spaces of possibility there is no longer a time arrow or linear order, the whole of the past is represented simultaneously. All aesthetics and all styles are present simultaneously and the challenge is to link these experimental spaces back to the users and their world. That means not only making them sensually and physically experienceable, but giving them sense in the first place and interpreting them subjectively and socially.

Artificial neuronal networks are currently the most interesting algorithmic representatives of the Kairos paradigm, although the Chronos paradigm tries to win back complete control over the networks through methods of "explainable AI" (XAI). Parallel to this, developing the Kairos paradigm means concentrating on the production of further embedding spaces and not on the recovery of control. My brief outline of the Kairos paradigm is probably unsatisfactory for both non-programmers and programmers. For the latter, code examples would be the most precise explanation. As the reader who seeks out this text is more likely to not be able to program, I have chosen the prose form, even if this means losing the precision that is actually necessary.

Authors' biographies in alphabetical order

Tobias Bieseke *is a research assistant at the Dortmund University of Applied Sciences and Arts in the storyLab kiU at the Dortmunder U (Center for Art and Creativity) and researches the potential of extended perceptions and narration for contemporary art. He experiments within the framework of artistic research and wanders on the threshold between artistic application and scientific investigation of new media. Since 2018, he has been undertaking his doctorate at the Academy of Media Arts (KHM) in the field of experimental computer science under Georg Trogemann. In 2023, he was able to make the success of his research visible for the first time, when he and Thomas Krupa won the German theater award "Der Faust" in the category of Genrespringer for the VR theaterproject "the wall 360°."*

Christian Heck *has been a academic-artistic staff for aesthetic and new technologies/experimental informatics, lecturer and doctoral researcher at the Academy of Media Arts Cologne (KHM) since 2017. His research and work focuses on peace research, aesthetic practice and AI critics. He is a member of the Forum Computer Professionals for Peace and Societal Responsibility (FIfF) e. V. and the German Informatics Society (GI).*

Mattis Kuhn *works on the reciprocal becoming of humans, machines and the shared environment. The focus is on text-based machines (as he describes currently himself as a text-based person) like algorithms, artificial intelligence, formal systems, software, and the intertwining of humanities, engineering and aesthetics. Essential aspects are non-/identity, decentralization and diversity, human-machine-environment entanglements, language and AI. He studied art at University of Art and Design Offenbach and Experimental Informatics at University for Media Art Cologne. He is currently artistic associate for Coding at Bauhaus-University Weimar and part of the ground zero research group at KHM Cologne.*

Steffen Mitschelen *is a design researcher and interface designer from Stuttgart, Germany, currently working as a UX designer and creative technologist at SAP. He holds a master's degree from the Merz Akademie, Stuttgart. As part of his PhD research at the KHM Cologne titled "Meta-tools," he conducts a series of workshops at various design schools, exploring the influence of design tools on the design work and designers' problem-solving capabilities. His work aims to provide a reflective basis for the understanding and conception of design tools.*

Zahra Mohammadganjee, *a Ph.D. candidate in Design Research at the Academy of Media Arts Cologne (KHM), also possesses a master's degree in product design from Sapienza University of Rome. Her passion lies in the characteristics of design knowledge, design process and design pedagogy. In her doctoral thesis, Zahra investigates the changing role of designers in the history of design, especially in two pioneering design educational approaches, D-school and Bauhaus, where she dissects the designer's field of action, tasks, and the definition of design knowledge in these two approaches.*

Christian Rust *is a PhD student at the Academy of Media Arts Cologne, where he conducts workshops in hands-on approaches to sound and obsolete media technologies. He holds degrees in musicology, philosophy, and computer science from Justus-Liebig-University Giessen. As a scholar in residence at the Deutsches Museum in Munich, he researched the bowed keyboard instruments in its collection. At the Greifenberg Institute of Organology, he explored historic techniques of instrument making through experimental archaeology and reverse engineering. He is currently developing an alternative interpretation of poiesis as a guest researcher at the Institute of Advanced Media Arts and Sciences in Ogaki.*

Somayyeh Shahhoseiny *is a design researcher holding a master's degree in product design from the Faculty of Architecture and Design of Sapienza University. She is currently pursuing a doctorate candidacy at the Academy of Media Arts in Cologne, and her work focuses on the human-space relationships through a phenomenological approach.*

Georg Trogemann *has been a Professor of Experimental Informatics at the Academy of Media Arts in Cologne since 1994. In 1977, he completed an apprenticeship as a carpenter. He studied computer science and mathematics at the University of Erlangen-Nuremberg, where he received his doctorate in 1990. From 1997 to 1999, and then later from 2004 to 2006, he was the pro-rector for research and infrastructure at the Academy of Media Arts in Cologne. His research topics include experimental algorithms, philosophy of technology, and the theory of artifacts. http://www.georgtrogemann.de*

Natalie Weinmann *is a Professor of Integrated Product Design at the University of Applied Sciences Coburg. Her ongoing research revolves around experimental design, fostering collaborations with colleagues in design, architecture, and natural science, bridging theory and practice. Her teaching philosophy underscores practical work and hands-on material experimentation, encouraging design students to nurture curiosity, adaptability, and a critical perspective on established norms. Simultaneously, she is actively pursuing her doctoral thesis at KHM Cologne, exploring how designers effectively navigate the unpredictable dimensions of the design process, drawing insights from her experiences in both higher education and practical settings.*