EVERYDAY ALGORITHMS

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Two roads diverged in a wood, and I –
I took the one less travelled by
Robert Frost

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Algorithms are precise instructions for solving problems that arise within various contexts using general schemes. We normally associate the term with mathematic or informatics challenges that are only relevant for engineers and software developers. But computer scientists like to emphasis that situations that require algorithmic solutions can, by all means, also be found in everyday life and knowledge of them helps them approach other problems efficiently. The examples that computer scientists like to use—how to share a cake fairly, how find the way out of a labyrinth, how to search the bookshelf for a particular book the quickest way or how to our pack our moving boxes in the most space-saving way—may actually arouse the curiosity of the layperson, but they are not particularly suited to making the importance of the algorithmic world for today's society clear. We generally make our way through life without knowing such processes or ever using them ourselves. The poignancy of algorithms becomes more powerful however when we remember that they also control, for example, airplanes, nuclear power stations and ATMs. But it is primarily the experts responsible for ensuring their safety and proper functioning who are in demand here. It would not only be asking too much, but also downright dangerous, to make them accessible to everyone. So what significance should algorithms have for our everyday lives?

We may get a first inkling of the hidden power of algorithms in everyday situations if we think about how Google's page-ranking algorithm, which determines which sources are listed at the top of a search, works. In a network of information that is no longer manageable in its entirety, only that which is found on the top spot or thereabouts exists. The decision governing the sequence is made by algorithms and very few users know the principle on which the listing of search results is based. We could name countless further examples that, taken as a whole, prove we increasingly delegate decisions of all kinds to machines. Programs make decisions about the sale of shares, they control production processes and assess medical data. Computer programs are therefore not only the new cheap labour force of society, they also sit in the decision-making committees.

But the hidden power of algorithms is not the central issue here, it is much more about the apparent analogies between information processing procedures and the eye-catching phenomena and processes in our everyday world. To this end we must first ask ourselves what information is in the first place and how it is possible to handle information mechanically. Only once the basic principle is recognised can we also see why the references between the phenomena in our technological environment and the algorithmic processing of information in computers are not false analogies, rather that both are actually rooted in the same principles. Furthermore we will establish that the transfer of human actions and thought processes to machines is successful if the action and thought can be dismantled by means of abstraction into a series of elementary and recombinable component activities and through doing so the context is limited in such a way that all decision alternatives that may arise in the action or thought process can be completely defined in advance. In this way we strip down goal-oriented actions into sequences of elementary, recombinable component activities; human actions and thought processes are disembodied and decontextualised. *Algorithms* are thus nothing other than disembodied patterns of formerly contextual action processes. Work in apprehension that has already been carried out is functionalised through algorithms becoming procedures that are transferrable to machines. We create a repeatability that does not need to be reflected upon again before each use. Different prerequisites are always in play, but these no longer need to be permanently updated. The successive abstraction of actions leads to building block systems, with which artefacts of any complexity can be assembled through the reiteration of basic elements. The product palette of building materials and the elements of programming languages find mutual roots in this. This inevitable fragmentation is just as visible in technological products, as it is in the associated production processes. Industrial products are always typified by disassembly and recombination, their external characteristic is the repetition of the same. These organisational principles of disembodied action thought are, in the meantime, ubiquitous and all pervasive. There is no area of our lives that completely denies this principle. We therefore find things all around us that are created by us dissecting our ideas of them and subdividing the associated production processes into sequences of the simplest actions. The standardisation of building parts makes sure they are compatible and almost infinitely recombinable. Such abstract basic elements of our action include s*equences*, *conditional loops*, *modularisations* and *hierarchies*. Against this background it is no surprise, but rather a necessary consequence, that we discover these principles and the traces that they leave behind not only in our computer programs, but also everywhere in the everyday products and processes of our technological environment.

What is information?

Imagine a heavy hammer; just waiting to be picked up and brandished. And imagine a strong, supple man, just waiting to grab the hammer, swing it over his shoulder and hit a heavy sheet of metal with it, which then starts to vibrate vigorously. This scene could, for example, play out in a dark shed somewhere in a backyard of a city, which otherwise dozes in the heat of a summer afternoon. At the same time you walk through a street very nearby and hear the hammer blow like a gong: this is a piece of information and everything else may be deduced from it.[1]

A man picks up a hammer in order to bash it against a heavy sheet of metal. The “Thesaurus of Exact Sciences” creates a tranquil scene from days of yore to introduce the concept of information. We feel like we have been taken back to a time when people still actually worked on and produced things with their hands. When one could still justifiably say things were *handiwork*, even if various tools or simple machines were used. Today we are, conversely, no longer primarily occupied with the production of tangible things, but rather with the creation, processing and distribution of *information*; of “unthings,” as Vilém Flusser calls them. But, one could agree that information as well as the processing operations linked to it—today one would say the *algorithms*—have always existed, in all areas. They were never bound exclusively to the computer, even if it may now appear so to some. It is precisely this that the image of the hammer-wielding workman refers to. Nevertheless, the image of

[1] Entry on the concept of “Information” in *Thesaurus der exakten Wissenschaften,* eds. Michael Serres and Nayla Farouki (Frankfurt am Main: Verlag Zweitausendeins, 2001), 411.

physical work and heavy materials refuses to fit to our idea of a society built on information and communication. Too great is the effort to make the sheet of metal vibrate, too tiny the resulting *information*. It is not only the tranquil small town and workman atmosphere or the sweating worker mechanically creating a gong that jars with us. We would find a young, dynamic information broker in a suit, his phone clamped between ear and shoulder, laptop in front of him, easier to accept. What bothers us much more though is the triviality of the resulting information, its unintentional nature. After further investigation, the message emitted will probably turn out to be the noisy byproduct of a manual working process, rather than calculated and differentiated communication.

However, the description precisely expresses a series of fundamental characteristics of the concept of *information*. Firstly, *information* must write itself into matter in order for it to be transferable and perceptible. If the information is not only to be transferred, but also preserved, this inscription must even leave permanent impressions in matter. Secondly, in order to become *information*, it requires an understanding recipient. For this the message must come upon a suitable "negative form" in the recipient and enter into a meaningful connection with pre-existent knowledge. Only those who hold the key to the message can give it a meaning. The ringing beat of the hammer has a different meaning for the incidental passerby than for the long-time neighbour. In short: *information* is only that which is understood and is very different depending on the recipient. And thirdly—for which our little story ends a decisive moment too soon—*information* is only that which shows an effect and changes something. The strength of the effect is not dependent on the amount of information, but rather exclusively on its relevance. If the gong, for example, always sounds at the same time, it could signalise that the time is such and such, upon which the recipient might make their way home as quickly as possible. The effect is the actual reason for all information. The manner of the effect varies greatly depending on which information processes we look at. In humans and animals it comprises of a change of behaviour, in computers in the selection of operations and in biological organisms perhaps in the reproduction of certain molecular structures. Information evaluation can be understood as a decision-making process. A message only becomes information through decoding, the decoding is based on a choice between alternatives. Here we come back to the introductory quote from Robert Frost. "Two roads diverged in a wood, and I – I took the one less travelled by." One can trace most information and decision-making processes back to forked-path situations.

Postulates on information
Material:
1. *Information* means imprinting form into material.
2. *Information* is the measure, for measuring the quantity of form in things.
Communication oriented:
3. *Information* is only what is understood.
4. *Information* is only that which entails a decision and has an effect.

As the word "in-formation" itself already suggests, it is primarily about *forms in things*. For Carl Friedrich von Weizsäcker *information* is the measurement, for measuring the amount of existing form, structure or shape. By means of information technologies we impress form into matter and thereby instruct—at times deliberately, at others inadvertently—brain and computer. These entities, informed in such a manner, then make decisions, in order, for their part, to carry out further actions and activities through which they create new information etc. This is the main activity of our information-based society. *Information* is now no longer a triviality or even side effect of our everyday activities, it is the central economic product. It does, however, make a difference whether we discover and describe information processes that were always there as such, for example in communications research, biology, physics and psychology, or whether we actively create new information processes by technological means, even if both approaches to research are intertwined with one another. It is not the scientific analysis, but especially the technological synthesis that currently orients all societal activity towards information processes and thus significantly influences our life and experience. In order to examine the information-based state of our "technological civilisation," we must take a look at the algorithmic processes behind the flows of information.

Programming Principles as Sediments of Society

> *Psychological structure, organisation structure and machine structure are petrified forms of social relationships.*
>
> Arno Bammé et. al.

If technology is the body of society, as Bernward Joerges states,[2] then information processes and communication networks are the body's nervous system. And we have as little direct access to the structure of our own nervous system, as we do to the streams of information and processes in technological networks, for which we require special knowledge and special measurement tools. Nevertheless we know that the structure of our nervous system determines our perception and thought, our being-in-the-world. Against this background we must ask ourselves how the inner structures of our societal nervous system—the data structures, networks, algorithms and processes—are involved in defining the state of our society.Information processing knows a variety of information carriers and associated action routines, whose historical development is marked by progressive abstraction and automatisation. In the beginning it was wall paintings, commandments on stone tablets, signals of smoke and fire or the like, then later books, telegraphs, flashing lights and the like. Today it is especially cultural technologies such as formal systems, digital codes and programming and on the side of devices mobile phones and digital computers, with which we transfer information and conserve knowledge. Viewed as media, information technologies cancel out distances and make knowledge permanent. They thereby generate their own time-space dynamic, within which information permanently emerges, is transformed, disappears and is occasionally rediscovered. Strikingly, some fundamental principles in the organisation of work processes reach far back and appear to have changed very little over millennia. The first big information systems, which functioned impressively in the form of bureaucracies, priesthoods and military groupings since the formation of the first states of antiquity, already knew hierarchical organisation as a means of effective control of complex processes. In such huge apparatus for the storage, transmission and use of information the necessity to process *information* presents itself directly in two ways. Firstly, it is part of the purpose of such organisations to collect *information*, to structure it and to make it available. Secondly, internal *information* is of decisive importance for the preservation of the organisation itself. Every system that stabilises itself has feedbacks and registers its own internal condition, in order to be able to deal with problems in good time. These meta-information processes are just as important for the survival of societal institutions as they are for modern networked and heterogenous information technologies.

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[2] Bernward Joerges, *Technik – Körper der Gesellschaft: Arbeiten zur Techniksoziologie* (Berlin: Suhrkamp Verlag, 1996).

Information processing always takes place on two levels simultaneously:
1. External information is registered, collected, structured, processed and outputted.
2. Internal information serves the preservation of the system. Information about the state of processing is registered and preserves the process via feedback mechanisms.

Everyone, even those without their own computer, is confronted with the elementary organisational principles of saving, transferring and processing information, both in the small private archive of information that everyone inevitably tends to nowadays (pictures, certificates, documents, programme booklets, telephone books etc.), as well as in the large social administration apparatuses, with which we—mostly unwillingly—communicate (tax offices, public transport systems, local councils, health insurance companies etc.). Everyone has used various elementary basic principles hundreds of times, for example when reading a timetable, sorting numbers, in the lexical search for a number in a telephone book or in filling out forms. Complex data structures such as lists, trees and pointers are to be found in everyday action routines far from the computer as well as in fundamental processing mechanisms. Everyone knows everyday routines in which certain activities must be repeatedly carried out, where progress is to be checked and compared to the previous pass each time. The process is then repeated until the desired result is achieved. This everyday mechanism is simultaneously the important basic figure of sequence control in programming.

Why is it that certain organisational and processing patterns have outlasted all technological progress to date and now find themselves inside computers? The most compelling explanation for the ubiquity and longevity of basic organisational structures assumes abstraction as the mutual origin of all principles. Abstraction means to prepare through the stripping away of the incidental and fluctuating to create a generally applicable basic structure of phenomena. In this understanding, methods are generally applicable rules for action, which allow us to select the most successful from an infinite number of alternative actions. Work towards understanding that has already been carried out is functionalised and becomes learnable, retainable findings and transferrable methods. "Formalisation is nothing other than the handiest kind of functionalisation of the already accomplished; but it is also potentially already technological, as that which can be formalised—that means: that which gains its applicability independent of the insight of execution—is essentially also already mechanised, even if the real mechanisms of its storage and regulated association were not already in place. All methods wish to create unreflected repeatability, a growing basis of prerequisites that is always in play, but does not always need to be updated."[3] The fundamental principles of information processing are the results of mechanistic thought, solidified into methods and a rational attitude towards the world.

Methods are generally applicable rules for our action, that enable us to choose the appropriate action from an infinite number of alternatives. If such methods, stripped down through abstraction, are formalised, we call them *algorithms*.

Algorithms are disembodied patterns of action of formerly context-bound procedures. Work towards understanding that has already been done is functionalised through algorithms and becomes learnable findings and methods transferrable to machines.

[3] Hans Blumenberg, *Wirklichkeiten in denen wir leben* (Stuttgart: Reclam Verlag, 1981), 41.

However, according to Alfred Sohn-Rethel, abstraction as the basic principle of mechanised thought is not a given a priori, but has its origin, again, in the social. According to Sohn-Rethel the principles of knowledge are "socialisation forms of thought that enable an individual of sufficient intelligence and education to employ a conceptually independent intellect or rationality that thinks for society. However, the individual themselves, especially the modern individual, sees their socialised thought conversely as their achievement, mysterious according to origin (god-given and yet god-denying), but autonomous and innate to them, ego cogitans, according to logic. According to our explanation however, these categories are socially preformed and therefore, as they reach the individual, given them in finished (but far from immediately identifiable) form, so as actual categories a priori and of course identically the same for all individuals of this society."[4] The authors of the book *Maschinen-Menschen, Mensch-Maschinen* argue in a similar way. They assume that there is a mutual third party, that shapes both the human as well as the machine. "These mutual third parties are socio-historic structural principles, which, mediated via constantly repeating interactions, sediment as psychological structure and become objectified in machinery and organisational structure. Psychological structure, organisational structure and machine structure are petrified forms of social relationships."[5]

But how can the results of the abstraction, the algorithms, which are initially intellectual substrates, now be transferred to machines? For this, mental processes must be translated into mechanical processes of action. The system of signs has a decisive role in this as the mediating authority. As the praxis shows, the disembodiments of human action patterns and their transferrals to machines is even surprisingly simple for almost all common production processes. In a simplified way we can say that the transfer of patterns of action to machines always succeeds if 1. the action can be cut up into a series of elementary and recombinable partial activities, and 2. the context can be limited in such a way that all alternative decisions that could arise in the course of action can, in principle, be predicted in advance. Insofar as concrete tasks allow this approach, we can realise independently acting objects by means of programming, whose respective pattern of action is not already inscribed permanently in the material construction of the object, but rather transferred as information from outside. We inform machines and delegate actions in this way. The intention still comes from humans, who mentally perform and plan the intended action in detail in advance. But the design is only the first part of every action. As soon as the design is formulated in suitable descriptions, we can leave the execution of the action, that is the carrying out of individual steps, to the machines.

In summary we can say: even if the amount of private and public information has grown drastically in recent times, our world was already permeated by signs, messages and information processes a long time ago. Indeed, the organisational and processing principles behind digital technologies were not invented for electronic machines, they are the fundamental results of human abstraction, which has its origin in social existence.

> *Sequences*, *conditional loops*, *modularisations* and *hierarchies* are abstractions of our dealings with each other and with things. It is therefore no surprise that we discover these principles not only in computer programs, but also everywhere in the everyday processes of our technological environment.

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[4] Alfred Sohn-Rethel, *Geistige und körperliche Arbeit* (Berlin: Suhrkamp Verlag, 1972), 21f.

[5] Arno Bammé et. al., *Maschinen-Menschen, Mensch-Maschinen, Grundrisse einer sozialen Beziehung* (Hamburg: Rowohlt Taschenbuch Verlag, 1983), 110.

The work of abstraction always purposefully dissects activities into sequences of elementary, recombinable component actions. Seeing "many of the same" in our surroundings is a first indication of the presence of disembodied patterns of action. The abstraction of actions and their subsequent transfer into artefacts leads to building block systems, with which infinitely complex artefacts and actions are composed from repeating basic elements. Building material activities and programming languages are both rooted in the same archetypal principle. So what is new and different about digital information and its electronic processing? To what extent is information today more "unthing-like" than in the past and have any socially relevant shifts even taken place through these new information technologies?

Signs & Algorithms

> *We have in software a special kind of sign. These signs are constantly and inescapably interpreted twofold, by humans on one side and by computers on the other, simultaneously and competitively.*
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> Frieder Nake, Das algorithmische Zeichen[6]

One possibility to characterise what is new about the computer is offered by the semiotic view of *information*, which subdivides signs, after De Saussure, into *signifier* and *signified*. If we understand the electronic computer as a type of machine that automatically processes signs, then the first striking novelty is on the side of the *signifier*, so on the material side of signs. Compared to traditional signs, such as texts, photographs, traffic signs or uniforms, electronic content loses its immediate materiality and tangibility. This is because *digital information* no longer enters into fixed bonds with the material, like ink and paper still did. Permanent objects are exchanged for ephemeral surfaces. This is possible because we no longer work with conventional forms, rather with tricky Janus forms. We divide the forms into two parts, one facing the machine and one facing the human. The form facing the machine is made up of two simple imprint stamps that we call 0 and 1. This pairing is universal insofar that infinitely complex forms can be imprinted with it. Universality is achieved through the repetition of the two base forms, whereby the actual information is defined through the position of the elements to each other.

Electronic information carriers are receptacles for taking in the elements of form facing the machine. That is the first, but not the only, dualism of the machine. The *dual base forms* 0 and 1 must also be imprinted in the carrier material, but the imprint remains ephemeral. Electronic memory cells are, to an extent, meta-forms that can take on either the one or other base form. We no longer have to decide which impression we leave behind permanently, rather can make as many changes to the imprint as we wish in temporal sequence. The large-scale consumption of electronic information is therefore no longer directly coupled with the use of material, like in print media for example, but rather with the use of the energy that is needed to change the imprints of the binary states. Through this *lightness* of the form we achieve the effortless movement of information through computer networks, while being duplicated or erased without a trace or apparent exertion an infinite number of times. The result is *floating* information, that can not be truly grasped, but rather appears as patterns for short moments only on the surfaces of the machine. It is intangible like light, smoke or acoustic signals, yet it is not characterised by its transience: it is permanently available and can be read out at any time through magnetisations, differences in voltage and

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[6] Frieder Nake, "Das algorithmische Zeichen," in *Informatik 2001: Tagungsband der GI/OCG Jahrestagung,* eds. Kurt Bauknecht, Wilfried Brauer, Thomas A. Mück, 2:736–42.

the like. This double existence leads to a bifurcation of the information structures, the visible forms and the surface and the hidden binary patterns on the inside of the machine.

Computer-based information is *Janus formed*, it is made up of two forms, one facing the machine and one facing the human.

The floating 0s and 1s, whose duality was chosen because it is especially suited for the internal play of the machine, has neither immediate meaning for the human, nor are they directly accessible in the computer. Even if we unscrew the lid of the machine, the information we are looking for does not come to light. It makes no visual, acoustic or tactile difference, whether a storage disk is full or brand new and empty. Even if we know that a certain piece of information must be there, it cannot be readily localised. Only the machine itself knows the organisational pattern and the current allocation of information fragments, and only the machine's routines have direct access to the binary pattern. In order to become *information* for the user and to create an effect, information must be transformed from this first mechanical existence back into a second existence comprehendible to the human. For this it is decoded by the machine itself and realised a second time in the interfaces (computer screens, speakers, gripper arms etc.). Only this second face of digital information—the pictures, sounds, texts, movements created in the interface—unfold its meanings for the user. If the access routines fail or the interface is broken, the information remains inaccessible and worthless, the matter becomes a digital emergency. At the same time we know that that which is shown on the surface is not the substance. This is to be found in the dynamic play of patterns on the inside, which seems to be realised effortlessly and escapes all observation. This accounts for the strange *unthingness* of digital information.

Computer-based information *floats*, it does not enter into fixed connections with the material and seems to move effortlessly through the networks. It is *fleeting* and only appears on the surfaces of the machine for short moments. Only here is it perceivable, interpretable and thus potentially meaningful for the user.

So we assign the first innovation in the digital to the *signifier*, i.e. the floating binary patterns described above. The Janus form of digital information, with its lightness and agility, accounts for a significant part of the power of the digital. However, it turns out that computer-based information is more refined than described thus far. Not only is the media content coded as binary pattern, but its processing routines are too. Digital codes no longer only inform humans, they also inform the machines. Actions are thus no longer confined to humans, but rather are executed in hybrid configurations made up of humans, things and signs. This condition is increasingly characterised by the expansion of independent activity by things and signs. The decisive innovation of the computer is that concrete thought and patterns of action must not already be structurally realised in the design, but rather that a metaform was found with the principle of programability, in which all conceivable disembodied action schemata can be retrospectively and repeatedly newly inscribed through simple series of signs, without us having to intervene in the inner structure of the machine again. We no longer build the concrete processing processes directly into the machine structure, but rather inform the machines as to what they should do.

We are now able to look back on more than fifty years of experimentation and experience with the concept of universal programability. In this time, a second qualitative leap has been initiated, which is now beginning to fully blossom. The originally monolithic computers (one computer—one program) have become ever more complex socio-technological action systems through the networking and reproduction of software-based activity carriers. The increasingly independent activity of technological artefacts and the accompanying allocation of activities to artefacts, humans and symbolic systems signifies a drastic break from conventional, rather singular and instrumental human-machine interaction patterns. As soon as mobile software units can, depending on the situation, be spread over networked artefacts, while acting relatively autonomously and exchanging information with each other as well as with the users according to cooperative rather than hierarchical patterns, serious problems of control arise, but also new degrees of freedom. We are still dealing specifically with algorithms, their mass proliferation, the increasing self-organisation of individual units, their interwoven and cooperative functioning and not least their reconnection with analogue material that takes place in the interfaces, leading to new qualities and contingent spaces of action. Through these expansions, algorithms increasingly work their way into the organic at the same time. As a general form of the specification of sequences, the idea of the algorithm is currently central for all those natural scientists interested in making their findings usable for synthesis, i.e. in turning previous analytical understanding into technological realisation.

> *Universal programability* means that we no longer build behaviour fixed into the structure of the machine, but rather inform them through codes (programs) what it is they should do. The *program* is the concrete realisation of abstract algorithms, customised for a specific machine.

The second innovation of digital processing schema—and here we again take up the semiotic perspective from the beginning of this section—can therefore be traced back to the *signified* and thus to the question, for whom the binary series of symbols mean something. Here the machines step up alongside the human as generators and processors of information.

The Perception and Meaning of Things

> *Near our holiday home in Tisvilde lives a man who has a horseshoe nailed above the front door of his house, which brings good luck according to old folk beliefs. When an acquaintance asked him: "Are you superstitious? Do you really believe the horseshoe brings you luck?" he answered: "Of course not; but I am told it works even if you don't believe in it."*
>
> Werner Heisenberg

Machines have continued to spew out mountains of homogenous products since the very beginnings of automation. We have entered a new phase with the dawn of the programable machine. Machines as well as everyday objects are increasingly becoming autonomous, interactive action objects, they do not simply offer a series of functions, but rather advance to complex fellow players. At this point we come full circle to the image at the beginning. We know that the power to shape a heavy sheet of metal no longer comes from human muscles, rather quite obviously from machines. It was this that made the tremendous increase in productivity during the industrial era possible. As early as 1987, at the transition to the so-called information era, Norman MacRae wrote in the *International Herald Tribune*, that seven times more goods were produced in the 40 years since the Second World War than during the whole cultural history of humanity before it.[7] The explosion in the number of things to that point was accomplished primarily by the population of the Western world. Today, as China, India and other (currently) low-wage countries have meanwhile engaged in production processes, the world of things has once again grown exponentially compared to 1987. Whether the products are manufactured by programmed machines or "programmed"

[7] Quoted (however it was actually calculated) in Joerges, *Technik*, 64.

low-wage workers is now only of interest as a monetary operand; the programming principle, i.e. the abstraction, dissection and re-synthesis of formerly contextual chains of action has long since been globally established. Labourers function like machines, they are the biological activity receptacles of algorithmic processes, who are to be optimised, like computer algorithms, in terms of efficiency and reliability. We can also be certain that algorithms and digital information processes are even involved in diverse ways in manually produced bulk products as soon as they are traded globally. This is the only way to provide the necessary infrastructures and to control the stupendous flow of products. The growth of things, which now obscure the world wherever we look, is inevitably accompanied by a conversely proportional loss in their meaning, as we can not reproduce our care and attachment in the same way. The more things that surround us, the less appreciation there is—on average—for the individual thing. The trend in costs appears to confirm this in a peculiar way. While information becomes more expensive, thing are sold cheaply on a huge scale. The power of states is no longer measured by their material production potential—as the example of European agricultural policy, which moved over to financially rewarding non-production long ago, confirms—but rather by the ownership of knowledge. Technological knowledge, medicinal knowledge, organisational knowledge, etc. Knowledge and functioning organisation processes are the decisive political, economic and social factors.

The exponential growth in availability of technologically manufactured products is in inverse relation to their *importance*. The more things that surround us, the less appreciation the individual thing experiences.
Social power is, consequently, no longer guaranteed by the possession of production capacities, rather by the *knowledge* behind it.

Science today looks at both organisations as well as organisms from a system theory perspective, as amalgamations of different elements that are in relational relationships with one another. From the abstract perspective of system theory, complex information processes take place not only in the inaccessible deep structures of information and communication technologies, but equally inside cells and nervous systems or in social and economic networks. As dynamic *systems*, no matter whether they represent nature, technology or society, they are always characterised by the principle of internal *information organisation* and *processing*. As is well known, such systems can only exist stably and permanently if there is a functioning material, energetic and informational exchange between the elements. Through science's system perspective it is possible to focus on information processes that previously remained undiscovered, because they reveal so little through superficial observations, like a university's flow of information is not revealed by observing its buildings, offices, lecture halls and furnishings. We are still in the process of trying to completely understand the information processes for physical and biological procedures. Even if these processes are not readily visible, their existence is undisputed. We sometimes forget that a comprehensive exchange of information already takes place on the surfaces of everyday objects—right in front of our eyes, ears and noses. By this we do not mean the contents of technological media, which are explicitly created for the specific exchange of information and are accordingly presented as conspicuously as possible, but rather the very ordinary everyday objects in our surroundings. The intentional, planned exchange of information by means of diverse information technologies is mostly colourful, loud and ostensible today. In the meantime, the visual field in inner cities is positively overflowing with competing information offers. There is no longer any "empty" space that is not trying to produce remote effects and to influence present or future decisions through a manifold offer of information.[8] If, as represented above, *information* is always in connection with decision processes, then our surroundings are now loaded with requests to make decisions, decisions which no one can keep up with any more, but on the other hand which no one needs to, because they are completely irrelevant to our behaviour in the concrete situations in which they offer themselves to us.

Such intrusive notifications, whose purpose is easy to see through, face the world of everyday things and speak another language. Most of the objects we are surrounded by remain *unreadable* to us, we only achieve a certain understanding—and then also only partially—in sensitive engagement with them. The real perception of things is also not secured by their presence alone, but requires either explicit reference—like the vial of strychnine needs the reference to its toxicity—or appropriation through repeated use, which is not recommended in the case of strychnine. The reduced perception of everyday things is based on our expectations and superficial contact with them. In contrast, deeper perception requires slow information processes. The Heideggerian "nearness of things", which encompasses all perceptions that first reveal themselves in daily use, requires time and admittance in order to develop. Linked to this is also the *self-will* of things, important for any practical work, which the user also only discovers through long-term contact.

But everyday objects can not be completely revealed, neither through direct perception, nor through repeated contact and empathy. Alongside their material manifestation and their goal-oriented function they also always possess further dimensions of meaning. Things are always media of non-verbal communication and are frequently used as such in everyday life, for example as carriers of messages about the characteristics and the status of the owner. Fetishes are another example of the complexity of objects. The horseshoe is granted a capability to effect independent from the belief of its owner: it possesses objective powers. Fetishes therefore even work if you do not believe in them.

In order to understand such meanings, we must learn to *read* objects. For this we must know the social conventions attached to them or imposed on them permanently. Semiotics therefore has never lead us away from the things, rather—on the contrary—has always shown the way to the truth of things. Even if some signs are understood across cultures, for example smoke as a symbol of fire, most allocations of meaning take place within the framework of culturally specific conventions. The special aspect of such historically and culturally determined references is their inconsistency, which leads to the fact that things in certain situations and at certain times are meaningful, but are not in other contexts. Henri Lefebvre described it as a repeated detachment of things from meanings. The problem of ephemeral attributions is on the other hand, however, an essential prerequisite for creatively handling things, allowing us to carry out ever new allocations of meaning. It is this loose link between sign and meaning that makes it possible to link things in new ways with our likewise changing imagination and thus to discover surprises in things time and again.

> The connections between things and meanings are subject to *cultural conventions*. They are temporary allocations that can break up and reform in new ways. Both the processing procedure in the computer and the assignments of meaning in the everyday world of things are of *semiotic nature*. We must learn to read both before we understand them.

One reading, which can be applied to both the processing procedures in computers as well as the everyday world, is to view them from the point of view of disembodied chains of

[8] As these offerings of information have never made an effort to integrate into the urban space, but rather see space merely as footprint, various cities and states have begun to ban outdoor advertising.

action, as not only algorithms, but also the whole industrial production and with that a large part of our environment is based on this principle. We must be aware, however, that meanings that we think we recognise in the things around us can always have two causes. They can exist objectively (measurable) or they can be associative attributions. Viewing nature from the point of view of technological design makes the problem clear. Adherents of the intelligent design theory are convinced that many traits of nature can be best explained through an intelligent cause, thus as a conscious production process.

Holzwege - Off the Beaten Track

"Wood" is an old name for forest. In the wood there are paths, mostly overgrown, that come to an abrupt stop where the wood is untrodden. They are called Holzwege. Each goes its separate way, though within the same forest. It often appears as if one is identical to another. But it only appears so. Woodcutters and forest keepers know these paths. They know what it means to be on a Holzweg.

Martin Heidegger, Off the Beaten Track

The fundamental mechanisms of information processing were already comprehensively installed in everyday life long before the informational science research programs on *pervasive* and *ubiquitous computing*. The well-informed observer will have long since registered them everywhere in their surroundings, in everyday things and in the patterns of activity. What is now new is the independent activity of things. The intellect, routined in the contact with information structures and algorithms, will be able to attribute the respective observations other meanings than the unschooled. It must be decided in each case whether individual phenomena are only metaphors and associations or real symptoms of hidden algorithmic processes. What we see with technological artefacts are, in any case, always material impressions of intellectual principles. As stated at the beginning, algorithmic routines inevitably leave behind traces in material through their objects and subjects of action. Only those who are able to take a step back and carry out the abstractions inherent in them once again can see these structures. Algorithmic everyday images can only be opened up via abstraction.

The maxim: "When your only tool is a hammer, every problem looks like a nail" comes from communication scientist Paul Watzlawick. A suspicion could grow in the mind of the observer of "algorithmic worlds" that algorithms are seen in places where none are at work. But it could also be the exact opposite. As most people only have a vague idea of concepts such as *information* and *algorithm* and there is no widespread understanding of the basic mechanisms, they are hard to spot in our everyday environment. But the organisational principles of disembodied action thought are ubiquitous and all pervasive. Things created by us stripping down the concepts of the objects into elementary building blocks and the corresponding production processes into sequences of the simplest actions are all around us. Through standardisation, the individual building blocks become compatible and almost infinitely recombinable. For complex artefacts and production processes, further organisational principles such as modularisation and hierarchisation are employed.

Computer programs are, just like technological artefacts, composed of elementary building blocks. The standardised blocks are compatible and diversely recombinable. Complex programs like complex technological products are manageable through hierarchisation and modularisation.

Fragmentation is as apparent in technological products as it is in the associated production processes, which are both distinguished by repetitions of the same. Dissection and recombination now characterise things and processes equally. Everyday processes can be precisely pre-structured, in that the scope of action in restricted so much that any possible decision alternatives that may arise in the course of events can be completely anticipated in advance. The execution itself then no longer requires thought, only rule-based decision.

> Like paths in a wood, algorithmic processes run along a rigid network of pre-determined paths. All forks in the path that the walker in the wood comes across belong to a carefully thought out system and they only appear as real decision alternatives to those unacquainted with the place. Algorithms are the transport networks for the controlled flow of streams of information.

What programmes cannot do is handle the uncertainties beyond the fixed paths, the untrodden terrain at the end of the beaten track is not accessible to algorithmic handling. Fixed paths no longer exist there, they are first created in the course of exploration through repeated use. Thinking and treading these paths remains the responsibility of the human.

The development of human and mechanical possibilities are two sides of the same coin. It is not only that machines that are tailored to the purposes of humans—with the advance of technology, the machine also shapes the human. Sociology states: "Technology is nothing other than the reflection of the human soul in nature become physical. Machines are produced by humans. They are nothing other than the materialisation of that which is already present, in the head and in the psyche of the human. Machines can be understood as materialised projections of essential traits of the human."[9] But that is only half of a cyclical dependency. We must also ask ourselves how the disembodied actions that now confront us in the environment as autonomous artefacts affect our psyche and our thought. At the same time, even closing this circle leaves open the question of how much space we wish to grant rational action thought, individually and socially, and whether we understand the programming and development of independently active artefacts purely as a technical or, for example, also as an aesthetic task. With the scientific institutionalisation of engineering, rational-mechanistic thought was also socially recognised. Alienated action thought as a technological mission was so successful that we now struggle with problems of over-production. The machines must be artificially slowed, because they spew out things and data that was always superfluous anyway, too quickly and in too great a number. The aesthetic side, in contrast, is left behind and underdeveloped.

Via some loops of reasoning and excursions, we have attempted to clarify why it is necessary and fruitful to grapple with information processes and algorithms, as two central concepts of our current world. Fortunately there is no lack of creative, playful and carefree approaches in the artistic dealing with information and communication technologies. What must be more strongly pronounced is a serious examination of the conditions of the possibility of technological action. Such an examination must be lead beyond technological euphoria and cultural pessimism. It is not only negligent and boring, but also dangerous to handle technology and culture as separate provinces of human creation. Technology is too powerful and life-defining to be left exclusively to the technicians. It can no longer be acceptable to deny our technological objects their own aesthetic worth. Yet aesthetic analysis aimed at the

[9] Bammé et al., *Maschinen-Menschen,* 110.

innermost structures of technological and scientific artefacts, and the creation of a connection between abstracting rationality and individual empathy that this would necessitate, is still considered by most as the wrong track to take.

The phrase "*auf dem Holzweg,*" "on the wrong track," describes a thought or action considered misguided and never leading to an acceptable result. Its use has always implied a call to the supposed stray to leave this track as soon as possible. In the standard sermons of the Middle Ages in Germany, *Holzwege* were the paths that lead straight to hell. But they can also be interpreted in another way. We remember Robert Frost: "Two roads diverged in a wood, and I – I took the one less travelled by." The alternatives are predetermined here. But where do these choices come from, who created the fork in the path? The paths in a forest, the *Holzwege*, are only paths because they are frequently used and trodden; they lead through more or less known terrain and are mostly relatively safe. It is the end of the beaten track that marks the crossover from known to undeveloped, the beginning of the impassable terrain. There, off the beaten track, one is forced to confront the inestimable or turn around. From this perspective, the beaten track is the safest and quickest feeder to the untapped, they lead us to where alternatives are not all already present as forks in the path.