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THE NEXT BIG DESIGN THING?

DR RER. NAT. DR PHIL. NORBERT A.

STREITZ

THE DEVELOPMENT AND IMPLEMENTATION OF SMART TECHNOLOGIES PLAY A KEY ROLE IN HUMAN-CENTRED DESIGN. THE PHYSICAL PRESENCE OF TECHNOLOGY AS WE KNOW IT TODAY, SUCH AS A COMPUTER AND A SCREEN, WILL CEASE TO EXIST IN THE FACE OF SIMULTANEOUS NETWORKING, INSTEAD BEING REDUCED TO SMART SURFACES.

THE SMART FUTURE, OR WHEN COMPUTERS BECOME INVISIBLE

Illustration *by JONI MAJER*
Photos *by RAMON HAINDL*
Questions *by PROF. DR BERNHARD E. BÜRDEK*

Mr Streitz ——— in fact, I should actually address you as Dr Dr as you hold two Ph.D.s, one in physics, specifically theoretical physics, and one in psychology, or cognitive psychology to be precise. How did you come to study these two very different fields and then to such an advanced level as to write a dissertation in each?

DR RER. NAT. DR PHIL. NORBERT A. STREITZ

I have been asked about this quite often. A detailed explanation would take too long, so I will give you the Reader's Digest version. At school I was very much interested in natural sciences, so I studied physics, mathematics and chemistry, first gaining a diploma degree in physics. In my doctoral dissertation I focused on Einstein's theory of general relativity, and this inevitably brought up some philosophical and epistemological questions, i.e. relating to theories of knowledge. In parallel, I was also interested in the problem-solving processes of scientists: for example, knowing what happens at a cognitive level when a mathematician sets about proving a theory and completes it successfully with Q.E.D. *(quod erat demonstrandum, meaning "thus it has been demonstrated")*. I therefore contacted the psychology research department at my university in Kiel and signed up for psychology in parallel, studying models of human problem-solving behaviour. In the end, I made psychology one of my two minor fields in my oral doctoral examination for my major in physics.

Afterwards, I went to the University of California in Berkeley, USA, as a postdoctoral fellow in the sciences. Using experimental methods, we investigated and compared how physics problems were solved by experts *(professors, which also included some Nobel Prize winners)* and beginners *(students)*. In the USA, the field of cognitive science was just emerging, combining psychology, linguistics, neuroscience and computer science, especially artificial intelligence. On my return to Germany, I accepted an offer from the Institute of Psychology at the Technical University RWTH Aachen for research and teaching in the area of experimental cognitive psychology. In this role, I applied my knowledge from physics about modelling and worked with my students to develop computer simulations of cognitive processes. After some time, I was told: *"If you want to be successful in psychology, you will also need to have a Ph.D. in the subject."* This is rather a typical German attitude, and so I wrote my second dissertation on the subject of cognitive science and knowledge representations.

However, in your work you have not remained solely in the field of psychology, but switched your attention to another area also of great relevance to our conversation today as well ——— namely, software ergonomics and more generally, designing the human-computer interaction.

DR RER. NAT. DR PHIL. NORBERT A. STREITZ

That's right. The area of human-computer interaction was still very new back then, but at the same time the logical further development of my psychological research. Inspired by the proliferation of the personal computer, we investigated how people solve problems with the help of computers. The interface between people *(as users)* and the computer needs to be designed in such a way that it enables them to concentrate mainly on the problems to be solved, while the interaction with the computer, especially the software, should not constitute a barrier. In the mid-1980s, we founded ——— in analogy to the field of hardware ergonomics ——— the special interest group on *Software Ergonomics* within the German Informatics Society *("Gesellschaft für Informatik")*. We specifically configured it as an interdisciplinary cooperation between computer scientists, psychologists, ergonomists and designers. To explore these issues in a wider context, I moved in 1987 to the newly established Institute for Integrated Publication and Information Systems *(IPSI)* of the GMD in Darmstadt, to help set it up and advance research as Division Manager and Deputy Director of the Institute.

The design of software and interaction with computers present new challenges for all, including, and especially designers. Even then, our credo was that people should be at the heart of all considerations, summarized as *human-centred design*. Later, I added the claim *keep the human in the loop*, which is becoming ever more important in the context of smart environments, such as the smart home, and corresponding automation trends.

Unfortunately, despite all the progress in areas such as touch-sensitive surfaces, for example, the viewpoint of human-centred design is not yet entirely widespread. Swiping a surface is not yet user-oriented per se. There are still many product developments which are primarily technology-driven, especially when we move away from the consumer product segment and turn to professional applications in the working world. There are often great discrepancies between the user experience in leisure applications as against in working life, in situations such as a bank, an insurance company or in an enterprise resource planning system.

Back then, I was already a staunch advocate of the concept that computers should be in the background as devices, because the real issue is designing the *human-problem interaction*. We called this *Cognitive Ergonomics*. In early 2000, we put this topic forward more fundamentally with the concept of the *Disappearing Computer*. This was also the name given to a comprehensive EU-funded Proactive Research Initiative of 17 projects, for which I had the honour and responsibility of being the Chair of the Steering Committee.

"Disappearing Computer" is a great term. However, if we look at the situation today, we do not get the sense that the computer is disappearing. Quite the opposite, in fact; they seem to be multiplying, and this trend only looks set to be further intensified by the widely propagated digitisation of all industry sectors. What are your thoughts?

DR RER. NAT. DR PHIL. NORBERT A. STREITZ

The concept of the *Disappearing Computer* is not about reducing the number of computers, but ensuring that these devices disappear into the background. I would make a distinction in this regard between physical disappearance in the sense of being invisible *(by being integrated in the environment)* and mental disappearance, whereby technology is integrated, but remains visible. Nevertheless, the fact that we are interacting with a computer is mentally dismissed. Interaction should be understood as interaction with an artefact, albeit with a *smart* artefact. The future lies in interaction with a smart environment, perhaps even to the extent that smartphones become superfluous.

That is a fascinating hypothesis. Do you consider this to be the new challenge for software and interface design? Can you provide some examples that illustrate it more clearly?

DR RER. NAT. DR PHIL. NORBERT A. STREITZ

Yes, of course. First, an example of mental disappearance. At the IPSI institute of GMD in Darmstadt, which later became part of Fraunhofer, we developed smart environments at the end of the 1990s, which we called *Roomware® (I have also trademarked the term Roomware®)*. This relates to the integration of information technology in the spatial environment, for example in walls *(DynaWall)*, in furniture such as tables *(InteracTable)*, armchairs, chairs, desks, lecterns *(CommChair, ConnecTables)*. By integrating displays, surfaces were transformed into interactive surfaces on which users could operate our software using fingers and pens, or interact through gestures. In addition, all Roomware® components were connected wirelessly. Application scenarios included cooperative group work, such as creative brainstorming or electronic meeting rooms, and informal communication across office buildings, in the hallway or cafeteria, for example. The general concept of these developments is the *Cooperative Building*, which means that the building behaves in a *cooperative* way towards residents / users and supports them through *(re)*active and adaptive environments. I have also paraphrased this concept as *smart spaces make people smarter*.

We developed the furniture-based Roomware® components in collaboration with the furniture manufacturer Wilkhahn and the wiege design studio. Wilkhahn later founded a spin-off, called foresee. Today, interactive tables and walls can be found in many different areas, from companies and trade fairs to TV programmes.

Our Roomware® components are examples of mental disappearance. Although the integrated displays are visible, they are not perceived as a separate computer. Users recognise our InteracTable as an interactive table with which they can interact, rather than as a computer in a table. The same applies, but to an even greater extent, to our DynaWall interactive wall, which can have several people standing in front of it and cooperating together. Interaction and cooperation activities can also take place between groups at distributed locations and different Roomware® components.

And what can you give as an example of physical disappearance?

DR RER. NAT. DR PHIL. NORBERT A. STREITZ

This brings us into the area of *smart materials*, whose characteristics can change dynamically and / or which have interactive properties: in the first stage, through a great number of integrated sensors and actuators, and in the next step, in terms of materials that possess new properties in themselves, such as adaptability, malleability or interactivity. In our application context, this means that we no longer need to integrate computer displays into a table, but instead buy an interactive tablecloth in the department store and place that on the table, or buy interactive wallpaper and stick that on the wall. Hey presto! An interactive wall.

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In this area, OLEDs *(thin light-emitting diodes made of organic semiconductor materials)* are leading the way. They have made bendable display screens possible today, but are still prohibitively expensive for large-scale applications. At the Consumer Electronics Show *(CES)* in January, the first *Wallpaper TV* was introduced, which is so thin and light that it can simply be attached to the wall with magnets. There are also developments in the area of smart textiles, which will facilitate *physical disappearance*.

New materials will enable new interaction metaphors and, conversely, innovative specifications will generate demand for new materials. Both will result in new challenges for the design of interaction. The existing interaction between humans and computers will be transformed into interaction between people and the environment. This is particularly evident when designing *Cooperative Buildings* and *Smart Cities*, another area I am working on.

In our discussion, the term "smart" has come up a number of times, while "intelligent" was mentioned less frequently. Is there a reason for this?

DR RER. NAT. DR PHIL. NORBERT A. STREITZ

I make a distinction because I prefer to use *intelligence* as a term for people, and *smartness* to characterise the capabilities of technical systems. That is also why I favour *smart*, to avoid the anthropomorphic connotations of *intelligent*.

Peter Sloterdijk says that intelligence is being bestowed on materials, and likens this to a reversal of genesis. Is intelligence really moving from people to objects?

DR RER. NAT. DR PHIL. NORBERT A. STREITZ

We have just touched on whether we should really speak of this as intelligence. Sloterdijk is seemingly referring to developments that characterise an active area of research which has been around for some time, with the terms *ambient intelligence*, *ubiquitous computing*, *smart environments* and the *Internet of Things (IoT)*. On the one hand, this is about orchestrating our environment, the world of things, with sensors and actuators and their connectivity. On the other hand, it is about software and algorithms that analyse, aggregate and evaluate collected data. The results then influence and change the environment via actuators. Of course, similar control loop concepts existed in the past *(cybernetics)*. A new development is the high number of ubiquitously distributed sensors, their integration and connectivity. Combining the scope of collected data with new methods, such as machine learning, allows for making inferences and drawing conclusions. Autonomous

driving and driverless cars are a manifestation of these developments because they can only work when the entire environment which is relevant for driving, such as roads, traffic lights, road signs, parking spaces and car parks, is sufficiently instrumented and connected to the vehicle. We might come back to this in the context of Smart Cities.

There will consequently be more *smartness* in the world, but that obviously does not mean that intelligence will be gone or will exit from people into the environment and that this becomes *more intelligent* than humans. Rather, what I said for *Cooperative Buildings* also applies to *Smart Cities: "smart spaces make people smarter."*

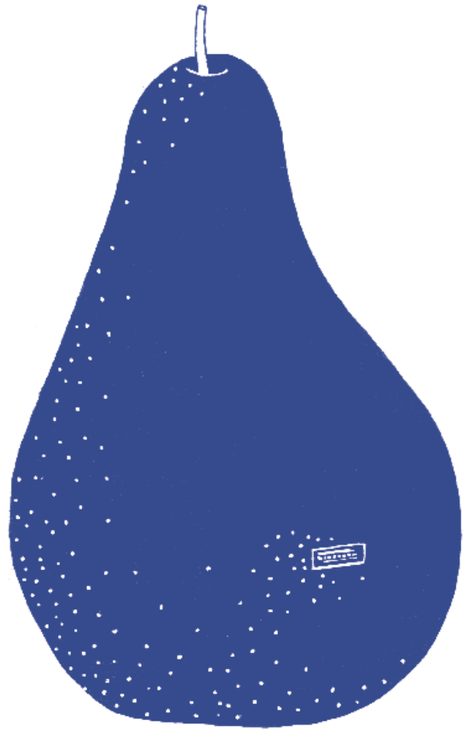
In relation to something you just mentioned. So many terms are currently floating around: smart products, artificial intelligence (which is presumably just refined algorithms?), robots for all walks of life, driverless cars, new technology for the workplace. Where has this current hype come from?

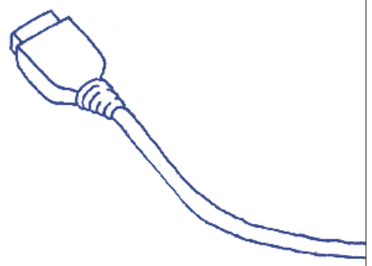
DR RER. NAT. DR PHIL. NORBERT A. STREITZ

You are right, there is a real hype and it is often fuelled by venture capital at present. However, it can also be regarded as the logical advancement of earlier developments. There has been research in artificial intelligence *(AI)* since the 1950s, with the famous conference in Dartmouth College back in 1956 often cited as the birthplace of AI. It should be also noted that there were already exaggerated expectations at the time, which is part of the basis of my own scepticism when it comes to the current hype. In 1957, Herb Simon predicted that a digital computer would be the world's chess champion within the next ten years. It actually took until 1997 for the IBM computer Deep Blue to finally beat the world chess champion Garry Kasparov in a tournament. This was a delay of about three decades. It was almost 20 years after this event that Google's AlphaGo beat the South Korean Go world champion in 2016.

An important sub-area was ——— and continues to be ——— machine translation of naturally spoken language, expectations for which were great even then. What few know is that a report published in the USA in the 1960s essentially stated that this was a hopeless endeavour and effectively suspended research for some 20 years. Only over the last ten years has progress been made for standard texts, which are often still rather clumsy and unnatural. Hopes are now pinned on artificial neural networks and machine learning, deep learning. In combination with Big Data, expectations are high once again.

Let us take a look at the current hype around autonomous driving. I have a simple example that is based on my own practical experience. The Speed Limit Info assistance system is supposed to show the driver the current speed limit while driving in real time. In my experience, this is only correct half the time, despite the fact that the recognition of road signs only requires relatively easy pattern recognition. And that is just one essential component. If we extrapolate current efforts in the area of driverless cars analogously to chess, Go and machine translation, then we can expect it to take quite a long time before real self-driving cars become part of our everyday life, especially in our busy and complex cities. What is likely to be possible sooner is





automated convoy driving, *platooning*, especially of trucks, which drive on the motorway at a set speed and in a defined lane. Shortly before they turn off at their respective exits, the trucks decouple from the convoy and the driver takes the wheel again to drive the truck to its destination in the city.

While we are on the subject of autonomous driving, a fatal crash involving a Tesla car has given rise to discussions on the ethics and morals of the field. Where is the debate today?

DR RER. NAT. DR PHIL. NORBERT A. STREITZ

On this subject, various things need to be considered separately. One is how control of the car is allocated to the human driver and the assistance system, as well as the subsequent responsibility for any consequences. In the case you mention, official responsibility was with the driver as he was not adequately controlling the *Autopilot* assistance system. However the car's, sensors failed to distinguish the truck and its trailer crossing the road and *thought* it was an overhead road sign. Other manufacturers have also had accidents which were caused by errors in the system. A second issue is the question, how good, i.e. how *smart*, are assistance systems? Again, my previous example about poor recognition of speed limits is relevant in this context. Building on this, there are legal and also moral issues of manufacturer responsibility. This means further clarification is needed on when an assistance system can be referred to as *autopilot*, because this is often taken as being equivalent to truly self-driving cars. The third aspect being discussed by legal and ethical experts is how a driverless car should decide in dilemma situations. Let's assume two options between which a system must choose. In both cases, it is highly likely that there will be fatalities, either of people walking across the street or the driver and his passengers. The situation can be further complicated arbitrarily through the variation of people and inclusion of children. What choice should the system make? It is worth remembering that real drivers who find themselves in such a situation where there is no *safe* way out are forced to make the same decision. People would base their decision on their own moral and ethical position depending on the situation. The driverless car can only decide on the basis of an algorithm.

Autonomous driving is to a great extent dependent on the collection and availability of data. What is the situation with regard to the control of these data and their evaluation? Who owns the data?

DR RER. NAT. DR PHIL. NORBERT A. STREITZ

That is a very important and interesting question. Let us take the assistance system for recognising speed limits as an example again. This is not yet autonomous driving, but a functionality that is required. As I discovered, the system is rather unreliable. Imagine the following situation: the system notices that I am driving

at 50 km/h, although I am *(allegedly)* only allowed to drive at 30 km/h. It has not detected that this restriction of 30 km/h only applies at night, from 10 pm to 6 am, despite this being clearly displayed on the sign, and that I am in fact driving during the day. It is worth noting that the recognition of additional signs or temporary restrictions for speed limits is specifically mentioned as a special feature of the *Speed Limit Info System*. As far as I know, nothing terrible has happened yet as a result. In the future, all data will be collected and might perhaps be transferred to my car insurance provider or the police. System errors could consequently cause serious problems for me and even have legal implications. That absolutely must not happen. As an owner and user of a car, I must have full control of any data that is collected and must also be able to turn the data collection system off.

The common and mandatory objective for all should be that I myself decide whether certain data is made available and whether I get added value from this in return or not. This brings us to the vitally important topic of *privacy*. In line with the fundamental right that has been been recognised in Germany since 1983 as the *right of citizens to self-determination (i.e. personal data belong to the citizens and cannot be collected without consent)*, I should retain control over the collection and use of my data. The private sphere must be respected. Unfortunately, we are seeing that many companies are not adhering to this, especially those with headquarters based outside German legal jurisdiction. Our requirement is referred to as *privacy by design* and will play an ever more important role in the context of future smart cities and the smart services that are offered.

Mr Streitz, we are reaching the end of our conversation. You mentioned the term "smart cities". Although we do not have time to go into great detail, could you share a few of your hopes and fears for this concept?

DR RER. NAT. DR PHIL. NORBERT A. STREITZ

To be very brief: the *Smart City* as a guiding theme for the future of our cities certainly has great potential, if we think of the possibilities of location-based services, for example. These offer current, location-specific services adjusted to meet individual needs. To do so, the provider must have a great quantity of data on the customer, in this case the citizens. Some will have actually provided this voluntarily on previous occasions, but for others it will be collected without their knowledge or permission. The extent to which data collection, from both commercial providers and public institutions, could get out of hand means we are at risk of becoming transparent citizens who no longer have any right to privacy. At the same time, we are being reduced to our data. In my vision of the city of the future, smart components are included. However, it is up to the individual how they want to use which types of services and what data they provide for any added value. It requires a trade-off that must be negotiated. Without going into greater detail here, I would advocate a *Humane, Social and Cooperative City* that is there for its citizens, supporting them in leading self-determined lives and giving them a range of options for exploiting their creative potential.

Thank you for this very inspiring conversation, Mr Streitz.