When Machines Decide

Werner Damm (left) and Martin Fränzle: “These systems have to be programmed to comply with ethical norms.”

Cyber-physical systems will change the world in the same way that the Internet has changed it, the two computer scientists Werner Damm and Martin Fränzle are convinced. Through this technology both everyday objects like refrigerators and complex systems like medical equipment and cars will be connected to intelligent control systems, communicate with one another and make their own decisions. The Oldenburg scientists are conducting research on the foundations of this technology and also working on an ethical concept for the machines to ensure that humanity is well served

Automation is advancing inexorably. Your work deals with the technological foundations of this process. Where is this journey going – and is mankind making itself redundant in the world of work?
Fränzle: That is a controversial issue in professional circles. Some experts are convinced that this is indeed the case and are therefore calling for a universal basic income. Others argue that historical evidence speaks against it. They point to previous industrial revolutions, which instead created radically new professional fields.
Damm: One way or another, big changes are imminent. In the field of transport, for example, where in the short or medium-term entire professions such as taxi, bus and truck driver will disappear.

Artificial intelligence seems to be only a matter of time. Where would you draw the line?
Fränzle: The most important thing is to have clear guidelines. It’s fantastic if a computer can learn on its own in order to assist us more and more in difficult situations. But the system’s behaviour has to remain predictable and oriented towards responsible actions based on social consensus. Otherwise we will have little use for the system.

In what areas do you expect to see most progress?
Damm: At the university we are researching how to technically optimize medical care and aftercare. Take intensive care units, for example, where staff is confronted with a flood of information. In addition to the heartbeat there are countless other vital parameters that indicate critical situations, but which often go “under the radar”. Indeed we know that 30 percent of deaths in post-operative phases could be avoided if personnel were in a position to create a meaningful overall picture from the vast amount of individual signals and the profound medical knowledge residing in large databases – with the help, say, of intuitive interfaces. This is a fantastic example of a meaningful way to collate information using cyber-physical systems.

Fränzle: A further research focus is the design of energy supplies. The fluctuations in the demand and supply of electricity are constantly controlled and balanced out already. But this task is becoming increasingly complex due to the rise in the supply of energy from renewable sources. What we need is systems that allow energy producers, storage systems and consumers to communicate with one another intelligently. The merging of the physical and virtual worlds can create entirely new possibilities for influencing this incredibly complex system. Electric cars as intermediate buffers for surplus energy or washing machines that turn on when power becomes available are just the beginning.

Prof. Dr. Werner Damm

A lecturer with Oldenburg University's Department of Computing Science since 1987, Werner Damm is head of the Safety Critical Embedded Systems division and Director of the Research Centre for Critical Systems Engineering. Damm established the Transportation Research and Development Division at the University-affiliated OFFIS Computer Science Institute and is also a member of its board. His work focuses on methods for the mathematically exact verification and analysis of safety critical embedded systems.

Damm: The third major area is autonomous driving with the aim of reducing the number of accidents, using resources more efficiently and minimizing emissions.

That is your focus. What exactly are you researching?
Damm: To name just one example: in Germany we are involved in a project funded by the Federal Ministry of Economics and Technology called Pegasus. It's about developing test standards, in other words generally accepted methods and tools for testing highly-automated vehicle functions. The focus is on systems that can take control for certain periods of time in specific situations. The idea is that the driver shouldn't have to monitor the technology the whole time and is therefore free to temporarily focus on certain other activities and side tasks.
Fränzle: That's the first step. At some stage the driving will be left entirely to the vehicle.

But surely not without the aforementioned test standards which the industry needs if it is to put such autonomous systems onto the streets?
Fränzle: The testing methods are indeed a colossal challenge and they are also one of our focus areas. We want to know how we can design software architectures and validation methods that meet the very high safety targets automation requires and prove that they have been met.

What does that mean exactly?
Damm: Take our just completed trans-regional collaborative research project AVACS. Here we proved the safety of traffic applications in all three areas – cars, airplanes and trains – using mathematical methods. So, in other words, we know how automated systems need to be built in order to remain controllable. Apart from that we are currently involved in ENABLES3 …

An EU-funded project …
Damm: Exactly. Focussed on the testing of highly automated systems. In this project we set up virtual test rigs in order to determine how an autonomous vehicle behaves in all conceivable scenarios. How well, for example, does the assessment of the situation operate, or the object identification? This means that even without test kilometres on the road we can examine whether and when a vehicle's reactions are adequate.

> "Technology only makes sense if it serves people"
> Werner Damm

Automation will ultimately turn car driving into a mobility service. Are people ready for this yet?
Fränzle: It depends. Are we talking about a situational autonomous driving system that only takes care of motorway manoeuvres from after entering via the slip road to just before the exit? With such a system I maintain my own driving skills, I can tray and test the system and build trust. Or does the car drive in fully automated mode? Then I could put my children into the car and tell it to drive them to music school. Here, people's reservations will be significantly higher.
Damm: On the whole, acceptance levels depend heavily on the extent to which a person can learn to trust the vehicle's autonomous driving function by selectively remaining 'in the loop'. It's important to remember that technology only makes sense if it serves people and is accepted by them.

One way or another, the vehicle takes on a huge amount of responsibility. Will automation really make roads safer?
Damm: This is a controversial issue. Let's just look at one statistic: around 3,500 people die on German roads every year. Due to human error – we get distracted or nod off, for example. So of course automation is superior to humans in this respect. Sensor systems are always active, and situation assessment is carried out on a permanent basis. Already today we can see around corners using so-called virtual horizons. On this basis we can safely assume that the number of accidental road deaths will drop significantly.

Mr. Damm, as a member of a working group for the ethics commission of the Ministry of Transport, you have been involved in drafting guidelines on automated driving. What was the objective here?
Damm: The challenge with highly automated driving is that everything that is otherwise decided by a human being is taken over by a vehicle, and this also goes for critical situations. The behaviour of the system has to be programmed accordingly. Two of the central questions that we discussed in the working group were therefore: How can we design decision-making so that it is clearly comprehensible and transparent for people? And how can we be sure that the decisions comply with society's values?

What results did the commission arrive at?
Damm: First of all, that people's lives are in principle more worthy of protection than things. Point two refers to the much-cited dilemma in which an automated car has to decide between two evils: does it drive into a group of two people or of five? In other words, can human lives be weighed against one another? The working group rejected this outright, in line with a decision by the Federal Constitutional Court on airplane hijacking and a discussion about whether or not to issue a warrant to shoot it down. In such cases the life of the passengers on board cannot be sacrificed to save the lives of a larger group of people on the ground.

Scientists at Oldenburg University can test assistance functions for self-driving cars in the University's driving simulator.

These are highly complex questions that certainly cannot be answered by computer scientists alone.
Fränzle: We are indeed in the midst of a paradigm shift. Before, as engineers we were used to building and analysing systems models that represented perfect blueprints of our software and hardware products. But when it comes to semi-autonomous driving, our models can no longer be perfect because the systems have to take into account human beings and their characteristics. Representing these is a necessary prerequisite to analysis of the dynamic interactions between people and machines.

> "Making machines comply with the rules that govern human actions"
> Martin Fränzle

So you also need input from others fields, and the social sciences in particular?
Fränzle: That's right, yes. Lessons learned from psychology, philosophy, sociology, and political and legal science. These systems have to be programmed to comply with ethical norms, for example.

So that might be a question for philosophy …
Fränzle: Exactly, because it's about making machines comply with the rules that govern human actions. In connection with the question about the conditions under which certain actions are required or forbidden.
Damm: Psychology, on the other hand, provides us with important approaches for explaining human behaviour, such as how can the technical system find out what a person intends to do? How can its attention be directed to a certain problem? And how can a system explain its decisions to people?

What about the liability of autonomous systems?

Prof. Dr. Martin Fränzle

Martin Fränzle has been a lecturer at Oldenburg University's Department of Computing Science since 2004 and is the head of the Hybrid Systems Division there. The computer scientist is also a head of division and scientific director at the Transportation Research and Development Division of the University-affiliated OFFIS Computer Science Institute. His main areas of research include mathematical models and the design, synthesis and verification of safe embedded computer systems.

Damm: This is an important aspect – and the situation is complex. After all, safety-related driving decisions are not based solely on information that comes from the vehicle itself, and for which the manufacturer shares responsibility. Information is also transferred from other vehicles via wireless communication. But what happens when the car in front of you perceives the world differently and delivers false information? Or if communication lines are hacked? Another point is that the autonomous system needs up-to-the-second map updates – and these come from the Cloud. Who checks that these maps have not been tampered with?

Fränzle: Another aspect is that globally implemented cyber-physical systems have to comply with all country-specific contexts. Regulations for the private sphere in Europe, for example, are very different from those in the United States. How can we design these systems so that their parameters adapt to comply with the framework of each individual society?

Is the necessary legal framework already in place here? Is automated driving legal?

Fränzle: Road traffic regulations have recently been updated to make it possible to authorize self-driving vehicles. But only on the condition that a legally traceable transfer of control between driver and technical system takes place and the human driver remains in the loop. The timing is good because this type of vehicle is already in the development phase.

Damm: The other good news is that the European parliament has passed an important resolution stipulating that whenever an autonomous system makes a decision that has safety implications, it has to explain why it took this or that action and also state the underlying principles. This guarantees the necessary transparency and prevents potential manipulations.

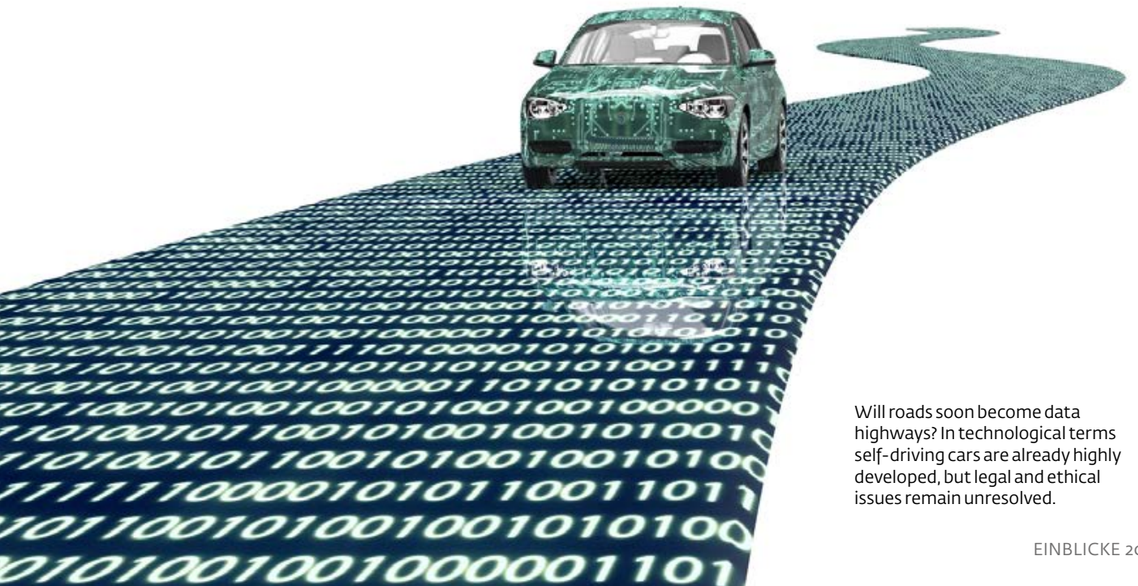
So the challenges are immense …

Damm: Yes. That's why we're working together with lots of partners – not only in research, but also from industry. Fortunately in Germany the climate for this is very constructive. Ultimately we all ask ourselves similar questions, such as what it means to use humane technology. Or how to integrate not only artificial intelligence into computer architecture, but also a social conscience.

So when will the first automated cars start driving on German roads?

Fränzle: For situationally autonomous vehicles, we should be ready in three to five years. But for safe, fully-automated driving everywhere we need a lot more time – and here even the most optimistic predictions from manufacturers vary in the extreme.

Interview: Corinna Dahm-Brey, Volker Sandmann



Will roads soon become data highways? In technological terms self-driving cars are already highly developed, but legal and ethical issues remain unresolved.